marconi instruments

OA 2090C

WHITE NOISE TEST SET

Instruction Manual

MP MASTER
MA31184

INSTRUCTION MANUAL
No. H 52090-930U
for

WHITE NOISE TEST SET

Code no. 52090-930U
comprising: Noise Generator TF 2091C
and Noise Receiver TF 2092C

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1976

MARCONI INSTRUMENTS LIMITED
ST. ALBANS HERTFORDSHIRE ENGLAND

NOTES AND CAUTIONS

ELECTRICAL SAFETY PRECAUTIONS

This equipment is protected in accordance with IEC Safety Class 1. It has been designed and tested according to IEC Publication 348, 'Safety Requirements for Electronic Measuring Apparatus', and has been supplied in a safe condition. The following precautions must be observed by the user to ensure safe operation and to retain the equipment in a safe condition.

Defects and abnormal stresses

Whenever it is likely that protection has been impaired, for example as a result of damage caused by severe conditions of transport or storage, the equipment shall be made inoperative and be secured against any unintended operation.

Removal of covers

Removal of the covers is likely to expose live parts although reasonable precautions have been taken in the design of the equipment to shield such parts. The equipment shall be disconnected from the supply before carrying out any adjustment, replacement or maintenance and repair during which the equipment shall be opened. If any adjustment, maintenance or repair under voltage is inevitable it shall only be carried out by a skilled person who is aware of the hazard involved.

Note that capacitors inside the equipment may still be charged when the equipment has been disconnected from the supply. Before carrying out any work inside the equipment, capacitors connected to high voltage points should be discharged; to discharge mains filter capacitors, if fitted , short together the L (live) and N (neutral) pins of the mains plug.

Mains plug

The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action shall not be negated by the use of an extension lead without protective conductor. Any interruption of the protective conductor inside or outside the equipment is likely to make the equipment dangerous.

Fuses

Note that there is a supply fuse in both the live and neutral wires of the supply lead. If only one of these fuses should rupture, certain parts of the equipment could remain at supply potential.

To provide protection against breakdown of the supply lead, its connectors, and filter where fitted, an external supply fuse (e.g. fitted in the connecting plug) should be used in the live lead. The fuse should have a continuous rating not exceeding 6 A.

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of mended fuses and the short-circuiting of fuse holders shall be avoided.

RADIO FREQUENCY INTERFERENCE

This equipment conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference.

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Fig. 1.1 Noise Generator TF 2091C and Noise Receiver TF 2092C

Chapter 1

General information

1.1 FEATURES

White Noise Test Set type OA 2090C measures both basic and intermodulation noise in multichannel f.d.m. telephony systems. A white noise signal simulating the multichannel telephone traffic is applied to the system baseband input and the noise introduced by the system into a 'quiet' measuring channel within the noise loading signal is measured thereby evaluating the noise performance of the system. Major application areas of the white noise test set include sub-assembly and system testing of multichannel f.d.m. carrier systems transmitted by radio-relay, tropospheric scatter, fixed satellites, coaxial land lines and submerged repeater cables. The test system is equally applicable to research, development, production, acceptance testing, maintenance and commissioning.

The test set consists of Noise Generator type TF 2091C and Noise Receiver type TF 2092C. As an alternative to White Noise Test Set type OA 2090B it retains the same high accuracy whilst providing faster measurement by means of auto-balancing with digital readout and facilities for fully automatic operation. Whilst the OA 2090C may be used within an automatic test system, the generator and receiver may also be used separately with any other receiver or generator conforming to the same international recommendations.

OA 2090C accepts all filters available for previous test sets in the OA 2090 series. When fitted with 'B' version filters, namely filters of the series TK 2094, TK 2095 and TK 2096, it conforms fully to CCIR Recommendations 399-2 and 482 (Geneva 1974). When fitted with 'A' version filters, namely filters of the series TM 7720, TM 7728, TM 7729 and TM 7730, it conforms to the earlier CCIR Recommendation 399 (Geneva 1963). The filters are, however, now housed in plug-in filter units which occupy the lower halves of each instrument. This arrangement permits easier changing of filters and rapid interchange between system capacities is facilitated by holding spare filter units already fitted with the appropriate filters.

Noise Generator TF 2091C is electrically similar to Noise Generator TF 2091B except that a.l.c. performance is improved, output level is adjustable in 0.1 dB steps and the instrument may be remotely controlled in all functions.

Noise Receiver TF 2092C provides the same basic accuracy as Noise Receiver TF 2092B but incorporates a digital display which may be selected in a wide variety of measuring units including noise power ratio and channel power in decibels referred to 1 mW or 1 pW. Channel power measurements may be made unweighted or with psophometric or C-message weighting and the addition of a transmission level attenuator allows display in channel power referred to the zero transmission level point e.g. dBm0p or dBrnC0. Outputs are provided in both digital and analogue form for recording on a printer or chart recorder, and the principle receiver functions may be remotely controlled.

Manual measurements are facilitated by the receiver automatically re-zeroing with n.p.r. units to changes in level. Cable connection between the generator and the receiver allows the band-stop filters to be automatically selected by the receiver channel selector buttons. For basic noise measurement, the generator noise on/off function is also provided at the receiver in this mode.

The generator and receiver may be remotely controlled from Control Unit TK 2085 - see Fig. 1.2 of Sect. 1.2. In this arrangement the majority of automatic test sequences are provided without incurring the high cost of a computer or tape controlled automatic test system. The control unit provides full manual remote control of the generator. In the automatic mode, level stepping over a preset range in adjustable increments and cycling through a selected number of measuring channels may be initiated locally at the control unit or remotely via an external remote start facility e.g. from a time clock. At each step on each channel a printout is provided of generator level, receiver display and channel number.

Since both the generator and the receiver are remotely controllable in all necessary functions, the white noise test set may be incorporated within a computer or tape controlled automatic test system where greater flexibility of measurement is required than is provided by Control Unit TK 2085.

1.2 DATA SUMMARY

Noise Generator TF 2091C (52091-930D) with Filter Unit TK 2087 or TK 2087/1

The generator may be fitted with up to nine filters. These include high-pass and low-pass filters corresponding to the baseband of the system under test, and band-stop filters for selected noise measuring channels - for details see 'Filter characteristics' below. This instrument may be used with either TF 2092B or TF 2092C Noise Receivers.

NOISE BAND	White noise is generated over the frequency band from below 1 kHz to above 12360 kHz. Complies with CCIR Recommendation 399-2 (Geneva 1974).
Characteristics :	Within the bandwidth corresponding to the baseband of the system under test the r.m.s. voltage of the white noise spectrum measured in a band of about 2 kHz does not vary by more than ±0.5 dB from 6 kHz to above 12360 kHz. At 1 kHz the r.m.s. voltage of the white noise spectrum is less than 3 dB down when measured in a bandwidth of 50 Hz.
NOISE POWER OUTPUT	
Noise power density :	Adjustable to above -14.5 dBm/kHz.
Peak factor :	Greater than 12 dB up to +15 dBm output level.
Total power :	Maximum is typically +20 dBm in bandwidths of 4 MHz and above.
Noise on/off :	Noise output may be switched off at the front panel. Noise power output drops by at least 60 dB. A warning lamp lights when the noise is switched off.
Level control :	Adjustable over at least ±0.5 dB relative to setting of thumbwheel switches.
ALC :	Maintains meter indication within ±0.1 dB of initial setting at constant ambient temperature when switching level and filters.
Meter :	Centre zero edgewise movement. When the meter indicates zero, the power output is as shown on the thumbwheel switches.
Meter range :	±0.5 dB.
Check level lamp : (over-range indicator)	Warning lamp is lit when meter is off scale and/or the output switches are set beyond range.
OUTPUT LEVEL	
Range :	Adjustable from +19.9 dBm to -59.9 dBm in 0.1 dB steps, controlled by thumbwheel switches.
Accuracy at 0 dBm :	±0.3 dB with meter indicating zero.
Additional error at other levels :	±0.5% of thumbwheel setting, ±0.1 dB.

OUTPUT IMPEDANCE — 75 Ω nominal.

Return loss : Greater than 20 dB for output levels below 0 dBm.
Greater than 26 dB for an output level of -10 dBm.

PROGRAMMABILITY

Manual/remote control : By front panel push-button. A warning lamp is fitted to indicate the remote control position.

Selection : Front panel controls for level, noise on/off, and filter selection become inoperative.

Output level : Controlled by a 12 wire signal.

± sign, 1 wire.
10 dB steps, 3 wires, b.c.d.
1 dB steps, 4 wires, b.c.d.
0.1 dB steps, 4 wires, b.c.d.

Filter selection : 3 wire b.c.d. signal for 5 or 6 band-stop filters.
4 wire signal for 4 or 3 band-limiting filters.

Noise on/off : Controlled by a single wire.

Control source : All programmable functions are controlled by feeding the appropriate signals into a socket on the rear panel.
All control functions are at 5 V t.t.l. level.

POWER REQUIREMENTS : 95 V to 130 V a.c. or 190 V to 260 V a.c., 45 to 65 Hz, 45 VA.

DIMENSIONS AND WEIGHT :

Height	Width	Depth	Weight *
188 mm	426 mm	482 mm	14 kg
7 3/8 in	16 3/4 in	19 in	31 lb

* without filters

Noise Receiver TF 2092C (52092-930Z) with Filter Unit TK 2086

The receiver may be fitted with up to six band-pass filters and six local oscillator boards - for details see 'Filter characteristics' below. This instrument may be used with either TF 2091B or TF 2091C Noise Generators.

OVERALL CAPABILITY

Number of channels : Up to six, push-button selected with lamp indication of channel in use.

Effective bandwidth : Nominally 2.2 kHz.

Sensitivity : Better than -130 dBm/kHz with 'B' version filters.
Better than -120 dBm/kHz with 'A' version filters.

Gain equalization : The gain of each channel is adjustable to give equal sensitivity.

MEASUREMENTS

Readout : Digital display of the following measurements by push-button selection :

(1) NPR in dB.
(2) Channel power relative to :

(a) 1 mW unweighted in dBm or dBm0.
(b) 1 mW psophometrically weighted in dBmp or dBm0p.
(c) 1 pW unweighted in dBrn or dBrn0.
(d) 1 pW psophometrically weighted in dBrnp or dBrn0p.
(e) 1 pW C-message weighted in dBrnC or dBrnC0.

For n.p.r. measurements the digital display is self zeroing for changes of reference level of up to ±19 dB.

Digital display : A maximum of three digits in steps of 1 dB with a maximum capacity of 159. Indication of polarity and measurement units.

Analogue display : Centre zero edgewise meter giving ±2.5 dB with 0.5 dB divisions or ±5 dB with 1 dB divisions, switch selected.

Hold : Locks digital display and attenuator to facilitate initial calibration and allows an analogue reading to be displayed relative to a fixed reference.

Transmission level : Adjustable between 0 and −49 dBr by means of a thumbwheel switch.

Input level : Warning of high or low input conditions outside operating range.

INPUT ATTENUATOR

Range : Automatically ranged in 1 dB steps. With 'B' filters at least 0 dBm/ch to -125 dBm/ch of which a max. of ±5 dB may be displayed on the meter.

Accuracy : ±0.5% of attenuation value ±0.1 dB.

Input impedance and return loss : 75 Ω. Return loss greater than 20 dB for input levels exceeding -100 dBm/ch.

INTERNAL STANDARD

Function : The internal standard is automatically applied to the receiver for calibration in the SET ZERO mode for absolute power measurements. Used in the INJECT 1 pW/CHAN mode to confirm receiver operation.

Characteristic : White noise generated over the band from 10 kHz to 13 MHz. Within these frequency limits the level does not vary by more than ±0.25 dB when measured in a band of about 2 kHz.

Noise power accuracy : ±0.5 dB at 1 pW (-90 dBm) per 3.1 kHz bandwidth.

LOCAL OSCILLATOR

Number of channels : Up to six local oscillator boards may be fitted.

Output : Rear panel socket for monitoring purposes.

RECORDER OUTPUT

Range : 0 to 3 V e.m.f. corresponding with -5 to +10 dB relative to centre zero of analogue meter.

Maximum current : 15 mA.

POWER REQUIREMENTS : 95 V to 130 V a.c. or 190 V to 260 V a.c., 45 to 65 Hz, 45 VA.

DIMENSIONS AND WEIGHT :

Height	Width	Depth	Weight *
188 mm	426 mm	482 mm	14 kg
7 3/8 in	16 3/4 in	19 in	31 lb

* without filter unit

Weight of typical filter : 0.6 kg (1 1/4 lb).

Weight of filter unit with full complement of filters and local oscillators : 7 kg (15 1/2 lb).

Program board 54490 032H (optionally fitted to Noise Receiver TF 2092C)

FUNCTION :

(1) TF 2092C in 'Remote control' mode :-

Allows : Remote control of channel selection.
Remote control of 'Set zero' command and 'Inject 1 pW/channel'.
Print-out of data on printer such as GMT 301-P16 (H1) or via computer with user's interface.

(2) TF 2092C in 'Manual' mode :-

Allows : Print-out of data on printer such as GMT 301-P16 (H1).

REMOTE CONTROL : Allows remote control of TF 2092C from Control Unit TK 2085 or other sources such as computer-controlled system with user's own interface.

Also allows measuring channels on TF 2091C to be controlled from receiver.

OUTPUTS :

(1) Print command : Logic '0' or '1' (selected by link).

(2) 'Print red' command (when input signal is high or low) : Logic '0' or '1' (selected by link).

(3) Units (dB) : 4 line b.c.d.

(4) Tens (dB) : 4 line b.c.d.

(5) Hundreds (dB) : Logic '0' prints '100'.

(6) 0.5 (dB) : Logic '1' prints '0.5', '0' prints '0'.

(7) Print 'Minus' sign : Logic '0'.

(8) Channel indicator : 3 line b.c.d.

(9) Switch generator b.s. filter : Logic '0' switches filter out.

(10) Select generator b.s. filter : 3 line b.c.d.

(11) Balance pulse (used in Remote Control Unit TK 2085 for interlock timing purposes) : Logic '1'.

PRINTOUT :

Printout consists of polarity and 3 digits with indication of 0.5 dB and channel number.

CONTROL INPUTS :

(1) Set zero : Logic '1' enables.

(2) Inject 1 pW/chan : Logic '1' enables.

(3) Print trigger : Logic '0' enables - pulse width between 100 ns and 80 ms.

(4) Select channel : 3 line b.c.d.

(5) Printer busy : Logic '0' or '1' (selected by link) from printer to hold data for duration of printout.
A third link position provides internal control for printers not having this facility, which holds data for a period determined by receiver clock rate (minimum approx. 1 s).

Inputs 1, 2 and 4 operational only with TF 2092C in 'Remote control' mode.

Inputs 3 and 5 can be used with TF 2092C in either 'Remote control' or 'Manual' mode.

PRINT COMMAND PULSE :

(1) Single shot mode : One command pulse of width 30 to 50 ms.

(2) Repetitive mode : Each command pulse, of width 15 to 25 ms, enables a printout. Repetition rate determined by receiver clock at approximately 5 s.

CODING :

BCD positive logic, t.t.l. compatible.

('1' is +2.4 V to +5.0 V),
('0' is 0 V to +0.4 V).

PROGRAM BOARD LINKS : Allows selection of printer commands by three links :-

(1) Print command : Positive or negative logic, single shot or repetitive mode.

(2) Printer busy : Positive or negative logic or internal.

(3) 'Print red' command : Positive or negative logic.

MAXIMUM DC VOLTAGES : Max. d.c. voltage applied to inputs : -0.5 V or +5.5 V.

Max. d.c. voltage applied to outputs : -0.5 V or +5.0 V (output in high state).

Overall equipment

Inherent intermodulation and noise : Measured as a back-to-back noise power ratio, i.e. with the generator output connected directly to the receiver input and with the power level not greater than that recommended by CCIR as the loading for the bandwidth in use when measured at a zero transmission level point (dBm = dBm0).

With 'B' version filters : better than 67 dB.

With 'A' version filters : better than 75 dB above 50 kHz and better than 70 dB at 50 kHz and below.

Control Unit TK 2085 (52085-900F)

The control unit specification is summarized below - see TK 2085 Instruction Manual for full specification.

Fig. 1.2 Control Unit TK 2085

CONTROL FUNCTIONS : Used in conjunction with TF 2091C and TF 2092C. Controls all programmable functions of each instrument.

Control of receiver : Channel selection. (Also selects corresponding generator channel.)
Set zero.
Inject 1 pW/channel.

Control of generator : Band-stop filter switching.
Band-limiting filter selection.
Output level. (Lamp lights when level is abnormal.)
Noise on/off. (Warning lamp is lit when noise is off.)

PRINTER OUTPUTS : Provides the following outputs to a printer.

Generator output level.
Generator level out-of-limits.
Channel selected.
Receiver output display.
Receiver out-of-range.
Measurement taken with noise off.
Print commands.

CYCLING FACILITY : Enables sequential measurements to be made at a range of levels on selected channels, either repetitively or by a single cycle.

Range of levels : -59.9 to +19.9 dBm. Initial level and total increment set on thumbwheel switches.

Level increments : 1 dB, 2 dB or directly from lower to upper limit.

Cycling priority : Measures at all level settings on one channel before moving to next channel. Printout occurs after each measurement. If a generator level warning occurs during a cycle the controller will reset to the lower level and move to the next channel. Display hold times of 0, 10 s or ∞ can be selected.

Remote starting of cycle : One cycle can be started by momentary closure of a contact.

Filter characteristics: ' B ' version filters

Band-limiting and band-stop filters of the TK 2094, TK 2095 and TK 2096 series meet CCIR Recommendations 399-2 and 482 (Geneva 1974) at the frequencies specified in these documents. At other frequencies the characteristics are derived by interpolation from CCIR Recommendation 399-2.

BAND LIMITING FILTERS
(TK 2095 and TK 2096 series)

Cut-off frequency * :	Nom. freq. (kHz)	Tolerance (kHz)	Nom. freq. (kHz)	Tolerance (kHz)
High-pass (f1)	12	±0.5		
	60	±1		
	316	±5		
Low-pass (f2)	60	±0.5	1796	±12
	108	±1	2600	±20
	156	±1	3284	±25
	204	±1.5	4100	±30
	252	±2	4892	±40
	300	±2	5600	±50
	408	±3	8160	±75
	552	±4	12360	±100
	804	±6		
	1052	±8		
	1296	±8		

Insertion loss :

Within pass band : Variation less than 0.2 dB in a band which includes the outer measuring channel.

Outside pass band :

Frequency	Loss greater than
0.8f1	25 dB
1.1f2	20 dB
1.2f2	25 dB

* Defined as the cut-off frequency of a hypothetical filter with square cut-off characteristics transmitting the same power as the practical filter.

BAND-STOP FILTERS
(part of TK 2094 series)

Characteristic :

Centre frequency in kHz (fo)	*Bandwidth, in kHz relative to fo, over which discrimination is at least:*			*Bandwidth, in kHz relative to fo, outside of which the discrimination does not exceed:*	
	70 dB (f5)	*55 dB (f4)*	*30 dB (f3)*	*3 dB (f2)*	*0.5 dB (f1)*
16	±1.5	±2.1	+2.7	+5	±7
40	+1.5	±1.8	+2.1	+4	–
56	±1.5	±1.8	+2.1	+4	–
70	+1.5	±2.2	+3.5	±12	±18
98	+1.5	±1.8	±2.1	+4	±9
140	+1.5	±1.8	±2.2	±5	+14
185	±1.5	±1.8	±2.2	±5	–
240	±1.5	±1.8	±2.2	+5	+21
270	+1.5	±2.3	±2.9	±8	±24
394	±1.5	±3.0	+4.5	±11	±35
534	±1.5	±3.5	+7.0	±15	±48
770	±1.5	±3.8	±8.0	±21	+70
1002	±1.5	±4.0	+9.0	+27	+90
1248	±1.5	±4.0	+11.0	+35	+110
1490	±1.5	±4.1	±12.0	±42	±135
1730	±1.5	±4.2	±14.0	±48	±155
1940	±1.5	±4.3	±15.0	+52	±175
2150	±1,5	±4,4	±17.0	±55	±195
2438	+1.5	±4.5	+19.0	±60	+220
3150	±1.5	±9.0	+22.0	+85	±285
3886	+1.5	±1.8	±3.5	+12	+100
4650	±1.5	±2.0	+3.8	±13	+120
5340	+1.5	±2.2	+4.0	±14	+140
6900	±1.5	±2.4	±4.4	±15	+185
7600	+1.5	±2.4	±4.6	+16	±200
9624	±1.5	±2.7	+6.0	+18	+250
10912	±1.5	±2.8	+6.7	+19	+280
11700	±1.5	±3.0	+7.0	+20	±300

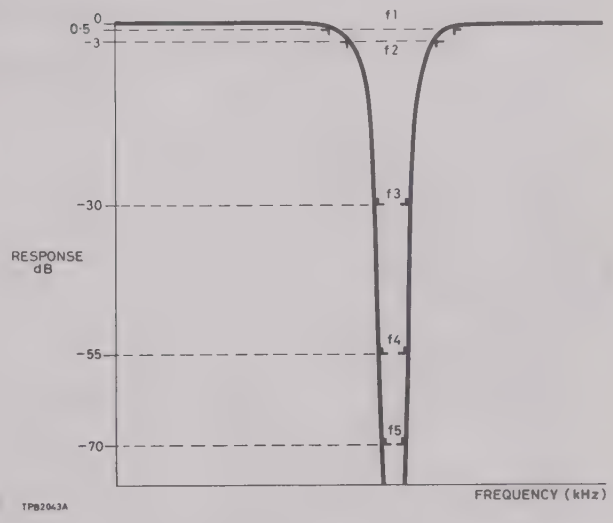


Fig. 1.3 Band-stop characteristic (TK 2094 series)

Band-stop characteristic, shown in Fig. 1.3, is relative to insertion loss at 10 kHz. Absolute insertion loss at 10 kHz, depending on filter, will be between 0.1 dB and 5 dB. In operation this variation is compensated for by the automatic level control circuit in the noise generator.

BAND-PASS FILTERS
(part of TK 2094 series)

Characteristic : Designed to suit the corresponding band-stop filter.

Filter characteristics: 'A' version filters

Band-limiting and band-stop filters of the TM 7720, TM 7728 and TM 7729 series meet CCIR Recommendation 399, (Los Angeles 1963).

BAND-LIMITING FILTERS
(TM 7720 and TM 7728 series)

Characteristic :

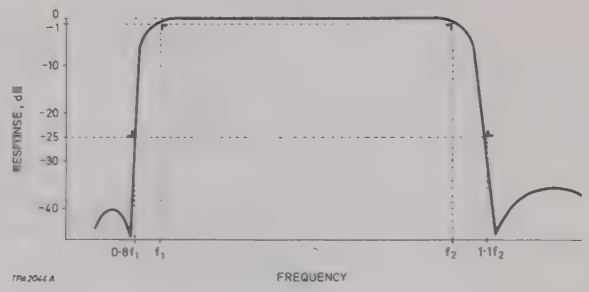


Fig. 1.4 Band-limited noise

Insertion loss : Within pass band : Variation less than 1 dB.

Outside pass band :

Frequency	Loss greater than
0.8f1	25 dB
1.1f2	25 dB

BAND-STOP FILTERS
(TM 7729 series)

Characteristic :

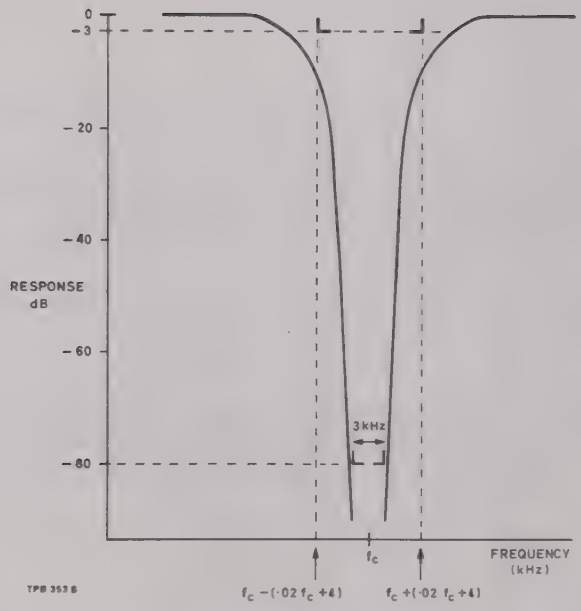


Fig. 1.5 Band-stop characteristic (TM 7729 series)

Attenuation is greater than 80 dB over a bandwidth of at least 3 kHz and greater than 3 dB at frequencies of (0.02 fc + 4) kHz from the centre frequency, fc.

BAND-PASS FILTERS
(TM 7730 series)

Characteristic : Designed to suit the corresponding band-stop filter.

Filter characteristics: Out-of-band filters

Out-of-band filter sets TK 2084 series consist of a band-stop filter, a band-pass filter and a local oscillator. The filter sets meet CCIR Recommendation 398-3, Geneva 1974, i.e. the attenuation of the band-stop filters exceeds 50 dB over a minimum frequency band of ±(0.005f + 2) kHz* (f being the centre frequency in kHz of the measuring channel). The additional attenuation, caused by the insertion of the band-stop filters at the lower and at the upper edges of the total multiplex signal band, does not exceed 0.3 dB referred to the additional attenuation caused in the centre of the multiplex signal band.

* Except when the centre frequency is 10 kHz; the minimum frequency band is then 10 ± 1 kHz.

'B' filters (CCIR 399-2 Geneva 1974)

Low-Pass Filter (kHz)	*Type*	*Order Code*
60 *	TK 2095/28	52095-328B
108 *	TK 2095/8	52095-094E
156 *	TK 2095/18	52095-318D
204 *	TK 2095/29	52095-329K
252 *	TK 2095/9	52095-104L
300 *†	TK 2095	52095-014P
408 *	TK 2095/12	52095-134Y
552 *†	TK 2095/1	52095-024A
708	TK 2095/34	52095-334Z
804 *	TK 2095/13	52095-144S
1052 *	TK 2095/14	52095-154C
1296 *†	TK 2095/2	52095-034L
1452	TK 2095/35	52095-335H
1548	TK 2095/21	52095-321D
1796 *	TK 2095/10	52095-114D
2044	TK 2095/33	52095-333A
2292	TK 2095/30	52095-330R
2600 *†	TK 2095/3	52095-044D
3284 *	TK 2095/11	52095-124B
3532	TK 2095/36	52095-336E
4100 *†	TK 2095/4	52095-054B
4892 *	TK 2095/19	52095-319T
5600 †	TK 2095/5	52095-064Y
5884	TK 2095/27	52095-327U
7284 ‡	TK 2095/22	52095-322T
8160 *‡	TK 2095/6	52095-074S
10164 ‡	TK 2095/23	52095-323P
11404 ‡	TK 2095/24	52095-324X
12360 †	TK 2095/7	52095-084C

High-Pass Filter (kHz)	*Type*	*Order Code*
12 *	TK 2096/2	52096-034X
60 †	TK 2096	52096-014E
316 †	TK 2096/1	52096-024G
564 ‡	TK 2096/5	52096-305D

Noise Measuring Sets (kHz)	*Type*	*Order Code*
16 *	TK 2094/9	52094-104R
40	TK 2094/10	52094-114U
56 *	TK 2094/11	52094-124V
70 *†	TK 2094	52094-014N
98 *	TK 2094/12	52094-134M
140 *	TK 2094/26	52094-326F
185 *	TK 2094/14	52094-154F
240 *	TK 2094/15	52094-164P
270 *†	TK 2094/1	52094-024W
394 *	TK 2094/16	52094-174A
534 *†	TK 2094/2	52094-034R
770 *	TK 2094/19	52094-204M
1002 *	TK 2094/20	52094-214H
1248 *†	TK 2094/3	52094-044U
1490	TK 2094/28	52094-328V
1730 *	TK 2094/17	52094-184L
1940	TK 2094/34	52094-334D
2150	TK 2094/32	52094-332S
2438 *†	TK 2094/4	52094-054V
3150 *	TK 2094/18	52094-294D
3886 *†	TK 2094/5	52094-064M
4650 *	TK 2094/27	52094-327G
5340 *†	TK 2094/6	52094-074H
6900 ‡	TK 2094/29	52094-329S
7600 *†	TK 2094/7	52094-084F
9624 ‡	TK 2094/30	52094-330G
10912 ‡	TK 2094/31	52094-331Y
11700 †	TK 2094/8	52094-094P

The specifications of the above filters are to the following recommendations :

* CCIR 482-1
† CCIR 399-3
‡ North American U-600 Plan, 1500, 2100, 2400 channel capacities.

NOTE. Noise Measuring Sets TK 2094 series consist of one band-stop filter for the noise generator and one band-pass filter and one local oscillator for the noise receiver.

'A' filters (CCIR 399 Geneva 1963)

Low-Pass Filter (kHz)	Type	Order Code
60	TM 7720/8	46857–118E
108	TM 7720	46857–109R
156	TM 7720/14	46857–124N
204	TM 7720/10	46857–120H
252	TM 7720/15	46857–125L
300	TM 7720/1	46857–111C
552	TM 7720/2	46857–112R
1052	TM 7720/11	46857–121E
1300	TM 7720/3	46857–113B
2660	TM 7720/12	46857–122U
4028	TM 7720/5	46857–115A
4188	TM 7720/13	46857–123Y
5564	TM 7720/9	46857–119U
8204	TM 7720/6	46857–116Z
12388	TM 7720/7	46857–117H

High-Pass Filter (kHz)	Type	Order Code
12	TM 7728	46855–006K
60	TM 7728/1	46855–005B
316	TM 7728/2	46855–004R

Noise Measuring Sets (kHz)	Band Stop	Band Pass	Local Osc.	Order Code **
14	TM 7729	TM 7730	TM 7793	52093–414V
27	TM 7729/21	TM 7730/21	TM 7793/4	52093–424M
34	TM 7729/12	TM 7730/12	TM 7793/2	52093–434H
40	TM 7729/1	TM 7730/1	TM 7793/1	52093–444F
56	TM 7729/13	TM 7730/13	TM 7793/3	52093–454P
70	TM 7729/2	TM 7730/2	TM 7794	52093–464A
105	TM 7729/3	TM 7730/3	TM 7794/1	52093–474L
185	TM 7729/4	TM 7730/4	TM 7794/2	52093–484D
245	TM 7729/22	TM 7730/22	TM 7794/9	52093–494B
270	TM 7729/5	TM 7730/5	TM 7794/3	52093–504H
342	TM 7729/16	TM 7730/16	TM 7794/6	52093–514F
534	TM 7729/6	TM 7730/6	TM 7794/4	52093–524P
1002	TM 7729/15	TM 7730/15	TM 7795/5	52093–534A
1248	TM 7729/7	TM 7730/7	TM 7795	52093–544L
2438	TM 7729/8	TM 7730/8	TM 7795/1	52093–554D
3886	TM 7729/9	TM 7730/9	TM 7795/2	52093–564B
5340	TM 7729/17	TM 7730/17	TM 7795/6	52093–574Y
8002	TM 7729/10	TM 7730/10	TM 7795/3	52093–584S
12150	TM 7729/11	TM 7730/11	TM 7795/4	52093–594C

** Order code specifies complete noise measuring set

Out-of-band filters (CCIR 398–3 Geneva 1974)

Noise Measuring Sets (kHz)	Type	Order Code
10	TK 2084	52084–014Y
50	TK 2084/1	52084–024S
119	TK 2084/2	52084–034C
270	TK 2084/3	52084–044E
304	TK 2084/4	52084–054G
331	TK 2084/5	52084–064X
600	TK 2084/6	52084–074Z
607	TK 2084/7	52084–084J
1499	TK 2084/8	52084–094T
1549	TK 2084/9	52084–104C

Noise Measuring Sets (kHz)	Type	Order Code
3200	TK 2084/10	52084–114E
3250	TK 2084/11	52084–124G
4715	TK 2084/12	52084–134X
4765	TK 2084/13	52084–144Z
6199	TK 2084/14	52084–154J
6300	TK 2084/15	52084–164T
9023	TK 2084/16	52084–174K
9073	TK 2084/17	52084–184N
13627	TK 2084/18	52084–194W

NOTE. Noise Measuring Sets TK 2084 series consist of one band-stop filter, one band-pass filter and one local oscillator.

1.3 ACCESSORIES

Accessories supplied — Code no.

One telephone plug for receiver — 23421-610M

Two mains leads — 43129-003W

Accessories available

Selective filter sets comprising band-stop filters, band-pass filters and local oscillator boards.
Band-limiting filters; high-pass and low-pass.
— See Sect. 1.2 above

NOTE. A filter unit as listed below is necessary for both generator and receiver for fitting the filters.

Programmable Filter Unit TK 2087 (for generator); to accommodate up to nine filters comprising 6 (or 5) band-stop and 3 (or 4) band-limiting. For use in either remote or manual generator mode. — 52087-900N

Manual Filter Unit TK 2087/1 (for generator); capacity as for TK 2087. For use in manual generator mode only. — 52087-901L

Filter Unit TK 2086 (for receiver); to accommodate up to six band-pass filters and local oscillator boards. — 52086-900C

Control Unit TK 2085; for remote control of generator and receiver functions.	52085-900F
Program board (for receiver) complete with lead, rear-panel mounting sockets and free plug, ready to assemble to receiver.	54490-032H
Matching transformer; 75 Ω unbalanced to 150 Ω balanced (was TM 5955).	54481-011C
Matching transformer; 75 Ω unbalanced to 140 Ω balanced (was TM 5955/1).	54481-021E
Coaxial lead; 1.8 m (6 ft) long with BNC plug at each end (was TM 4726/260).	54351-011F
Multi-way connecting lead; 1.2 m (4 ft) long with 36-way plug at each end. For interconnecting control unit to generator, or control unit to receiver or generator to receiver.	43129-144X
Multi-way connector kit, comprising two 36-way plugs to be wired by the user.	46883-271K
Front panel cover for generator or receiver.	41690-079Z
Rack mounting conversion kit for generator or receiver.	54127-131M
Carrying case for generator or receiver.	54112-101T
Carrying case for filter unit.	54112-091V
Carrying case for filters and oscillator boards.	54112-071R
Dummy front plate to fit in unused filter position in generator or receiver.	54134-011A

1.4 UNPACKING AND REPACKING INSTRUCTIONS

Retain the container, packing materials and the packing instruction note (if included) in case it is necessary to reship the instrument.

If the instrument is to be returned for servicing attach a label indicating the service required, type or model number (on rear label), serial number and your return address. Pack the instrument in accordance with the general instructions below or with the more detailed information in the packing instruction note.

(1) Place a pad in the bottom of the container.

(2) Place pads in the front and rear ends of the container with the plywood load spreader(s) facing inwards.

(3) Put the polythene cover over the instrument and place it in the container with the front handles and rear projections (where applicable) against the plywood load spreaders.

(4) Place pads in the two sides of the container with cushioning facing inwards.

(5) Place the top pad in postion.

(6) Wrap the container in waterproof paper and secure with adhesive tape.

(7) Mark the package FRAGILE to encourage careful handling.

If the original container or materials are not available, use a strong double-wall carton packed with a 7 to 10 cm layer of shock absorbing material around all sides of the instrument to hold it firmly. Protect the front panel controls with a plywood or cardboard load spreader; if the rear panel has guard plates or other projections a rear load spreader is also advisable.

Chapter 2

Operation

2.1 PRINCIPLES OF OPERATION

Standards concerning both the design objectives and the actual performance of telephone systems are probably generated by most telephone organizations throughout the world. Standardization of such matters as modulation plans, pilot frequencies and levels, translation and distribution equipment transmission levels, etc., are essential to provide system compatibility within a telephone organization. International standardization becomes vital for links across national frontiers and systems conforming to CCITT or CCIR recommendations are designed to prevent incompatibility. Many national organizations also adopt CCITT and CCIR recommendations for their national systems.

Standards not only cover the 'mechanics' of telephone systems to ensure compatibility but they are also very much concerned with the quality of service. One of the most important areas of quality is that of the signal-to-noise ratio at the telephone receiver. Recommendations have therefore been produced which specify the noise performance objectives of complete telephone systems.

Some of these noise objectives are summarized in 'Multichannel Communications Systems and White Noise Testing' published by Marconi Instruments. This publication is referred to elsewhere in this manual as the 'White Noise Book'.

Such noise objectives are of obvious relevance to the ultimate system user since he can readily translate them into equivalent interference noise at the telephone receiver. However, for precise specification of multichannel f.d.m. equipment performance, and for testing during research, development, production, commissioning and routine maintenance, they present a measurement problem. The total noise appearing within the system baseband comprises both basic noise, due to system thermal effects, path loss, etc., and intermodulation noise which is caused by system non-linearity and is a function of the traffic loading level. It is therefore necessary to simulate the traffic loading in order to adequately prove the equipment's performance. A form of measurement is required which can be carried out rapidly under accurately controlled conditions and will provide consistent results which can be related to the system noise objectives.

Studies of the characteristics of multichannel signals have shown that they may be closely simulated by loading the system with random noise of uniform spectrum (white noise) which is band-limited to the band occupied by the telephone channels within the f.d.m. baseband. The relevant characteristics of multichannel signals and white noise are discussed in Chapters 5 and 6 of the White Noise Book.

White noise testing (or noise loading) of an f.d.m. system to measure the intermodulation noise performance is carried out with a white noise test set (or noise loading test set) which consists of a noise generator and a noise receiver.

The noise generator generates broadband white noise variable in level and limited in bandwidth by means of high-pass and low-pass filters. The measurement technique consists basically of inserting a series of generator band-stop filters one at a time into the band-limited white noise. These filters introduce 'quiet' measuring channels at the system baseband input which become 'noisy' due to basic and intermodulation noise as they pass through the system.

At the output of the system a narrow band white noise receiver tuned to the frequency of the generator band-stop filter then measures the noise in the 'ideally quiet' measuring channel. Common practise is to locate measuring channels close to the bottom, middle and top of the baseband and also at one or two intermediate points. Frequencies of available measuring channels and characteristics of both the filters and the test set itself are specified by both CCIR and CCITT.

The principle of white noise testing is illustrated in Fig. 2.1 for a measurement expressed in noise power ratio. In (A) the noise receiver is adjusted to give a readout of 0 dB as the reference level with the band-stop filter out. In (B) the noise receiver automatically balances to the level in the measuring channel after insertion of the band-stop filter and displays the n.p.r. in digital form.

Alternatively the receiver may be standardized against an internal reference source of 1 pW/channel and then display the noise in the measuring channel in absolute or relative units of channel power. The following measuring units may be selected in addition to n.p.r.

dBm	dBm0
dBmp	dBm0p
dBrn	dBrn0
dBrnp	dBrn0p
dBrnC	dBrnC0

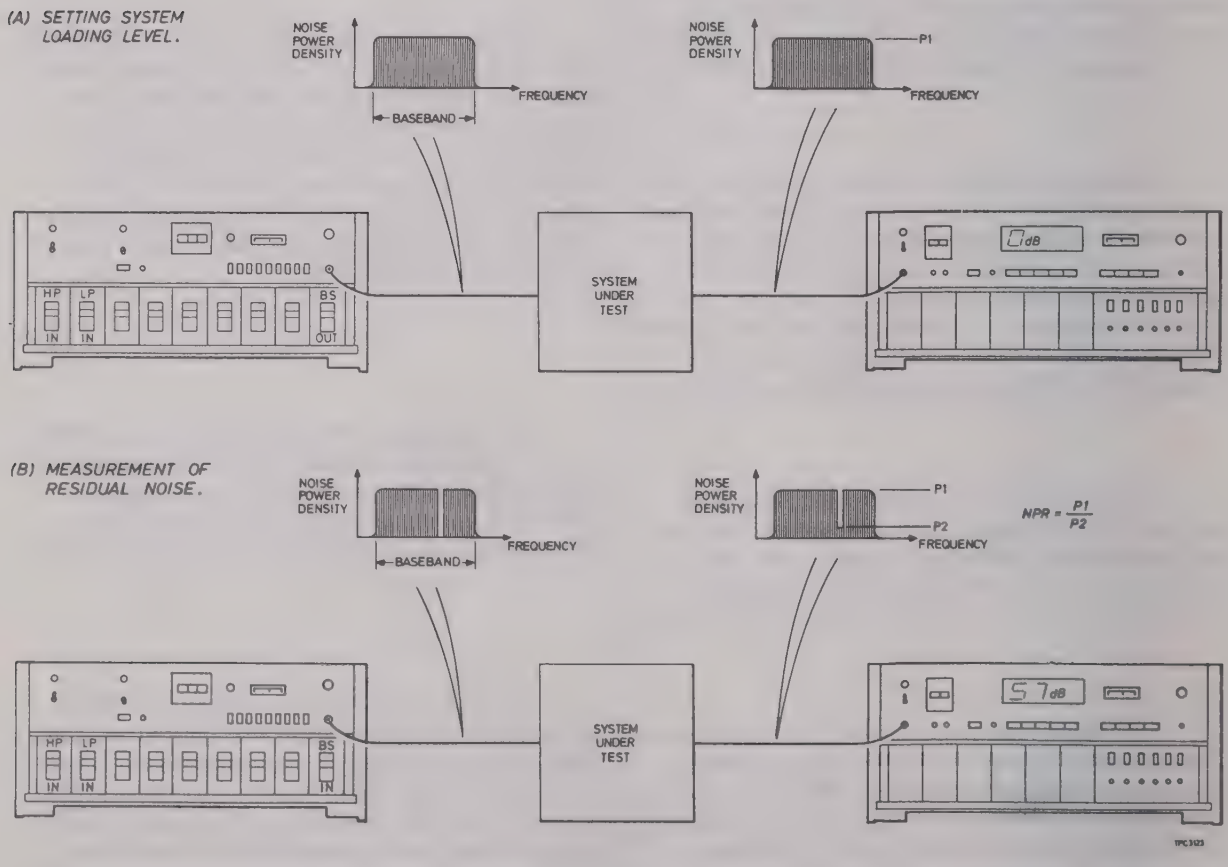


Fig. 2.1 Principle of white noise testing (measurement in noise power ratio)

(HP = high-pass filter, LP = low-pass filter, BS = band-stop filter)

The readout consists of a 3 digit l.e.d. display with polarity and measuring units indication. A meter allows interpolation between the last digits and b.c.d. output to drive a printer is optionally available.

2.2 PREPARATION FOR USE

2.2.1 Installation

In common with other apparatus employing semiconductor devices, the performance of the instruments may be affected if they are subjected to excessive temperatures. Therefore, completely remove the plastic covers, if supplied, and avoid using the instruments over, or near to hot equipment.

2.2.2 Power supply

The test set is normally supplied with the mains selector switches on each instrument set for supply voltages within the range 190 to 260 V. For input voltages within the range 95 to 130 V, the selector switches on the rear panels must be moved to the 115 V setting from the previous 230 V setting. Do this by unscrewing the plate securing the switch button, pressing the switch to the required position, reversing the plate and replacing it to hold the switch in the new position. Attach a suitable 3 pin plug to the supply lead, noting that the wires are colour coded as follows.

Connection	Colour
Line (phase)	Brown
Neutral	Blue
Earth (ground)	Yellow/Green

2.2.3 Selection and fitting of filters

To equip the white noise test set to conform with the latest recommendations for in-band testing, i.e., CCIR Recommendation 399-2 (Geneva 1974) or CCITT Recommendation G228 (Geneva 1972) for radio-relay or cable systems respectively, select 'B' version filters as listed in Table 2.1.

Table 2.1

System capacities and 'B' version filter frequencies for radio-relay and coaxial cable systems (CCIR Recommendation 399-2)

System capacity (channels)	Limits of band occupied by telephone channels (kHz)	Effective cut-off frequencies of band-limiting filters (kHz)		Frequencies of available measuring channels (kHz)
		High-pass	Low-pass	
60	60–300	60 ± 1	300 ± 2	70 270
120	60–552	60 ± 1	552 ± 4	70 270 534
300	60–1300 64–1296	60 ± 1	1296 ± 8	70 270 534 1248
600	60–2540 64–2660	60 ± 1	2600 ± 20	70 270 534 1248 2438
960	60–4028 64–4024	60 ± 1	4100 ± 30	70 270 534 1248 2438 3886
900	316–4188	316 ± 5	4100 ± 30	534 1248 2438 3886
1260	60–5636 60–5564	60 ± 1	5600 ± 50	70 270 534 1248 2438 3886 5340
1200	316–5564	316 ± 5	5600 ± 50	534 1248 2438 3886 5340
1800	312–8120 312–8204 316–8204	316 ± 5	8160 ± 75	534 1248 2438 3886 5340 7600
2700	312–12 336 316–12 388 312–12 388	316 ± 5	12 360 ± 100	534 1248 2438 3886 5340 7600 11 700

For fixed satellite services according to CCIR Recommendation 482 (Geneva 1974) use Table 2.2.

If the test set is to be equipped to the older CCIR Recommendation 399 (Geneva 1963) select 'A' version filters as listed in Table 2.3.

Table 2.2.

System capacities and 'B' version filter frequencies for fixed satellite services (CCIR Recommendation 482)

Capacity (channels)	Limits of band occupied by telephone channels (kHz)	Effective cut-off frequencies of band-limiting filters (kHz)		Frequencies of recommended measuring channels (kHz)
		High pass	Low pass	
24	12- 108	12 ±0.5	108 ±1.0	16 98
36	12- 156	12 ±0.5	156 ±1.0	16 140
60	12- 252	12 ±0.5	252 ±2.0	16 240
72	12- 300	12 ±0.5	300 ±2.0	16 270
96	12- 408	12 ±0.5	408 ±3.0	16 240 394
132	12- 552	12 ±0.5	552 ±1.0	16 240 534
192	12- 804	12 ±0.5	804 ±6.0	16 394 770
252	12-1052	12 ±0.5	1052 ±8.0	16 534 1002
312	12-1300	12 ±0.5	1296 ±8.0	16 534 1248
372	12-1548	12 ±0.5	1548 ±10	16 534 1002 1490
432	12-1796	12 ±0.5	1796 ±12	16 534 1002 1730
492	12-2044	12 ±0.5	2044 ±14	16 534 1248 1940
552	12-2292	12 ±0.5	2292 ±17	16 770 1730 2150
612	12-2540	12 ±0.5	2600 ±20	16 770 1730 2438
792	12-3284	12 ±0.5	3284 ±25	16 1002 2438 3150
972	12-4028	12 ±0.5	4100 ±30	16 1002 2438 3886
1092	12-4892	12 ±0.5	4892 ±40	70 1002 2438 4650
1872	12-8120	12 ±0.5	8160 ±75	70 1002 3150 5340 7600

Table 2.3

System capacities and 'A' version filter frequencies

System capacity (channels)	Limits of band occupied by telephone channels (kHz)	Centre frequencies of in-band measuring channels (kHz)		
12	12-60	27	40	56
24	12-108	40	70	105
36	12-156	40	70	105
48	12-204	40	105	185
60	12-252	40	185	245
*60	60-300	70	185	270
*120	60-552	70	270	534
240	60-1052	70	534	1002
*300	60-1300	70	534	1248
*600	60-2660	70	1248	2438
*960	60-4028	70	2438	3886
*960	316-4188	534	2438	3886
1200	316-5564	534	3886	5340
*1800	316-8204	534	3886	8002
*2700	316-12388	534	3886	12150

NOTE. It is normally recommended that 'A' and 'B' version filters should not be mixed in the same white noise test set - see Sect. 2.2.4.

For out-of-band testing of radio relay systems select filters from Table 2.4 (CCIR Recommendation 398-3) and for fixed satellite services use Table 2.5 (CCIR Recommendation 481).

Filter type numbers are listed in the data summary and all frequencies listed in Tables 2.1 to 2.4 are available as standard for the OA 2090C. The majority of the out-of-band filters listed in Table 2.5 are, however, only available to special order.

Filters are housed in filter units which plug into the lower half of the generator or receiver as follows.

Generator

Programmable Filter Unit type TK 2087
Manual Filter Unit type TK 2087/1
} either may be fitted to the generator - see Sect. 4.4

Receiver

Filter Unit type TK 2086

The generator filter units house high-pass, low-pass and band-stop filters and the method of fitting is described in Sect. 4.4.

The receiver filter unit houses band-pass filters and local oscillator boards. Methods of fitting are described in Sects. 4.5 and 4.6 respectively.

Table 2.4

Out-of-band filter frequencies for radio relay systems (CCIR Recommendation 398–3)

System capacity (number of channels)	Limits of band occupied by telephone channels (kHz)	Frequency limits of baseband (1) (kHz)	Centre frequencies (f) of noise measuring channels (kHz)		
			Below	Above	
				(a)	*(b)*
24	12–108	12–108	10	116 or 119	(2)
60	12–252	12–252	10	304	(2)
	60–300	60–300	50	331	(2)
120	12–552	12–552	10	607	600
	60–552	60–552	50	607	600
300	60–1300	60–1364	50	1499	1549
	64–1296				
600	60–2540	60–2792	50	3200	3250
	64–2660				
960	60–4028	60–4287	50	4715	4765
900	316–4188	60–4287	270	4715	4765
1260	60–5564	60–5680	50	6199	6300
	60–5636				
1200	316–5564	60–5680	270	6199	6300
1800	312–8204	300–8248	270	9023	9073
	316–8204				
2700	312–12 388	300–12 435	270	13 627	13 677
	316–12 388				

(1) Including pilots or frequencies which might be transmitted to line.
(2) These values will be indicated after more practical experience has been gained.

Table 2.5

Out-of-band filter frequencies for fixed satellite services (CCIR Recommendation 481)

System capacity (number of channels)	Limits of band occupied by telephone channels (kHz)	Centre frequencies (f) of noise-measuring channels (kHz)
24	12– 108	116
36	12– 156	172
60	12– 252	277
72	12– 300	331
96	12– 408	448
132	12– 552	607
192	12– 804	884
252	12–1052	1157
312	12–1300	1499
432	12–1796	1976
612	12–2540	2794
792	12–3284	3612
972	12–4028	4430
1092	12–4892	5381
1872	12–8120	8932

2.2.4 Combinations of 'A' and 'B' filters

The test set will accept either 'A' version or 'B' version filters as described in Sect. 2.2.3. However, because of the different specifications, the filters are not electrically interchangeable in that it is safest to use either all 'A' version or all 'B' version filters in a test arrangement. For optimum accuracy 'B' version filters are recommended. The major differences between 'A' and 'B' version filters and their effects upon measurement accuracy are described in Chapters 8 and 9 of the White Noise Book. It is permissible, though causing reduced accuracy, to use 'A' version band-stop filters with 'B' version band-pass filters and local oscillator boards since the wider slot of the 'A' version band-stop filter allows the instrument n.p.r. to be maintained. The convers arrangement must not be used since the band-stop filter will be narrower than the band-pass filter and intermodulation may arise in the receiver. Permissible combinations are illustrated in Fig. 2.2.

2.2.5 Modes of operation

Various modes of operation are possible with the white noise test set.

Manual operation

In this mode, there are no connections between the generator and receiver. The generator may be fitted with either Programmable Filter Unit type TK 2087 or Manual Filter Unit type TK 2087/1.

For the other modes of operation, the programmable filter unit must be fitted and the receiver must be fitted with a program board as described in Sect. 2.4.2.

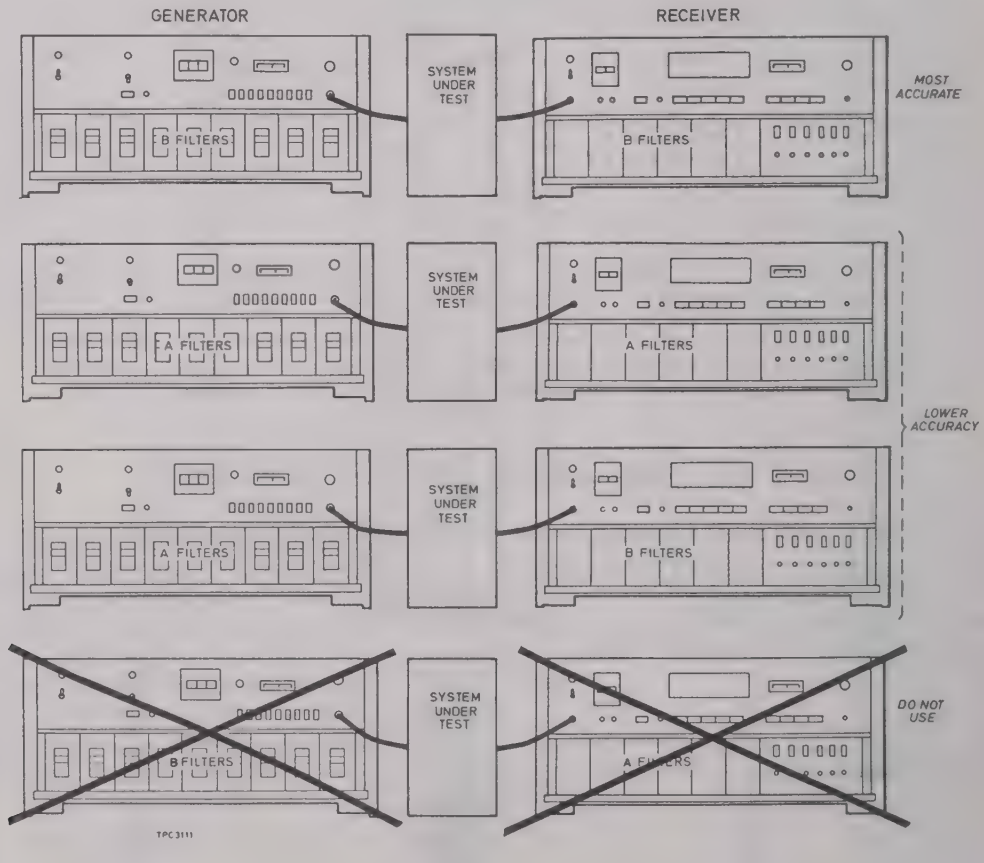


Fig. 2.2 Permissible combinations of versions of filters

Generator/receiver interconnection

Connection between the generator and receiver by a multi-way cable transfers control of band-stop filter selection to the receiver. This mode allows faster manual operation and is described in Sect. 2.4.3.

Printer connection

A printer may be connected to the receiver in either of the above modes. Printout of the receiver display and channel number is provided and connection requirements are described in Sect. 2.4.4.

Generator/receiver control from Control Unit type TK 2085

The control unit controls all remotely controllable parameters of the generator and receiver. Its facilities are summarized in the Data Summary and Sect. 2.4.5. For detailed description, see TK 2085 instruction manual.

Remote control of generator and receiver

The test set may be remotely controlled from a computer or tape controller as part of an automatic testing system. This mode is described in Sect. 2.4.6.

2.3 AREAS OF APPLICATION

2.3.1 Baseband to baseband

The commonest application of white noise testing is from baseband input to baseband output. During research, development or production, cable terminal equipments may be tested by connection back-to-back. In the case of radio systems, the transmitter may be connected to the receiver at r.f. or i.f.

For commissioning or routine maintenance of a system operating between two points A and B there are two common techniques for baseband to baseband measurement. The first technique requires a white noise test set at both ends of the system. The A to B direction is checked with generator A and receiver B; the B to A direction with generator B and receiver A. This test requites two operators in communication between A and B on a 'supervisory pair' or 'order wire' which is not part of the system under test. It does, however, measure the performance of the system separately for either direction of transmission.

The second technique, normally known as 'loop round', requires one white noise test set and one operator. The baseband output at point B is connected through to the baseband input, that is, looped round. In radio systems the connection may alternatively be at i.f. The noise generator and receiver at point A then measures the overall performance of the system for the A to B and B to A directions. For commissioning this is often sufficient since if the system is within specification overall it may be expected also to meet the performance requirements for each direction separately.

For fault location during maintenance, however, it is clearly preferable to test the two directions of transmission separately. 'Loop round' measurements can also be made separately on the equipment at each site. In the case of radio systems this may be at i.f. or at r.f. in which case a 'loop round' mixer with a shift oscillator is necessary to convert from transmit to receive frequency.

2.3.2 Baseband translation equipment

On modern submarine cables, the one cable is used for both directions of transmission with a 'HI' band for B to A and 'LO' band for A to B. The cable may be tested by transmitting noise in the 'HI' band from B simultaneously with noise in the 'LO' band from A.

The baseband inputs at either terminal are both at 'LO' band with up conversion of the B to A baseband at B followed by down conversion at A. The baseband from A to B passes through the terminals at either end without frequency translation. The terminals plus cable are therefore tested by transmitting noise in the 'LO' band simultaneously in either direction with noise applied at B prior to up conversion. A similar technique is used to check the terminals back-to-back prior to installation.

To check the B terminal separately in the B to A direction requires non-standard noise measuring channels in the white noise test sets. The tests are accomplished by equipping the noise receiver with band-pass filters and local oscillators at frequencies in the 'HI' band equivalent to the 'LO' band frequencies of the band-stop filters. Similarly, 'HI' band band-stop filters are provided at point A to coincide with 'LO' band channels in the noise receiver enabling the A terminal to be tested in the B to A direction. Standard techniques are used for tests in the A to B direction since no frequency translation occurs.

For example, the 1840 channel CANTAT II cable from UK to Canada was commissioned with MI white noise test sets using this technique.

2.3.3 Multiplex and demultiplex equipment

Both the standard techniques of Sect. 2.3.1 and the special arrangements of Sect. 2.3.2 test the systems capability between baseband input and output. This type of measurement is the most common application of white noise testing. However, multiplex and demultiplex equipments may be tested using similar techniques. For back-to-back measurements, however, all inputs to the translation equipment must be loaded with uncorrelated white noise that is several noise generators will be required.

For example, to test a group translation equipment, five noise generators in the band 60 to 108 kHz are connected to the five separate group inputs. The supergroup output of the multiplex is connected to the input of the demultiplex equipment and a noise receiver then tests each group output in turn. Supergroup translation equipment similarly requires five noise generators and three are required for mastergroup translation equipment.

It is possible to test the multiplex and demultiplex equipments separately using a similar technique to that of Sect. 2.3.2 to allow for the frequency translation of the noise slots. Testing of the demultiplex, of course, requires only one noise generator. This test is rarely carried out however, since it is the overall performance that is of significance.

2.3.4 System components

Individual components within the telephone system (e.g. amplifiers, repeaters, modems etc.) may be tested using white noise loading. Such components are likely to have an n.p.r. which is relatively high in comparison with the overall system. Where the n.p.r. of the unit under test approaches that of the white noise test set itself a correction is necessary. The measurement technique is described and a correction chart given in Sect. 2.14 of this manual.

2.3.5 Noise measurements in actual traffic (out-of-band testing)

Evaluation of system performance by white noise loading is ideal during the R & D, production and commissioning phases of a system. For regular maintenance purposes, however, it has the disadvantage of requiring the telephone traffic to be transferred to a standby channel. International recommendations exist for a noise measurement technique known as out-of-band testing (see Sect. 2.13), which can be carried out during the transmission of actual traffic. A measuring channel is located approximately 10% outside the baseband and a band-stop filter at this frequency is inserted permanently at the system input to minimize noise due to incoming circuits. A white noise receiver tuned to this channel continuously monitors the distortion noise occurring due to the traffic loading in the baseband. The measuring channel may be above the baseband in which case it will be more sensitive to changes in thermal and intermodulation noise in the r.f. and i.f. sections of radio systems. Locating the channel below the baseband will generally give levels more sensitive to changes in the multiplex and demultiplex equipments.

Since the measurement is made during actual traffic transmission its accuracy is limited due to the variable nature of the traffic loading level and the fact that effects within the baseband can only be predicted rather than measured directly.

2.3.6 Broadband recorders

A tape recorder may be regarded as a single channel wide band amplifier and for certain applications white noise effectively simulates the normal signal. The intermodulation performance of the recorder is measured in an identical fashion to that of a telephone baseband with the noise loading bandwidth chosen to match the recorder's operating bandwidth. Slots are inserted and n.p.r. measurements made in the normal manner. An example of this type of application is in the testing of equipment used for the recording of signals in missile and space vehicle telemetry.

2.4 REMOTE CONTROL AND PRINTER OPERATION

2.4.1 General

As described in Sect. 2.2.5 of this manual, various modes of operation are possible. In addition to manual operation, limited generator control from the receiver via a cable connection is provided. In both these modes a printer may also be connected to the receiver. Remote manual or automatic control is provided by Control Unit TK 2085 or the generator and receiver may be included within an automatic test system under computer or tape control.

Sects. 2.4.3 to 2.4.6 describe the methods of interconnection for these modes of operation.

2.4.2 Program board

For remote control and/or printer operation optional accessory Programme Board 54490-032H must be fitted in the instrument. The programme board is supplied complete with multi-way connector(s) wired to the board and a spare 36-way plug is also supplied. Fitting instructions are given in Sect. 4.7 of this manual.

2.4.3 Generator and receiver interconnection

Connection is shown in Fig. 2.3. Connect the REMOTE CONTROL socket on the rear panel of the generator to the GENERATOR (TF 2091C) socket on the rear panel of the receiver using optional accessory lead type 43129-144X. If the generator is to be located more than 1.2m from the receiver, a longer lead must be wired. Optional accessory kit type 46883-271K contains two Amphenol type 57-30360 36-way plugs for this purpose. The lead should be wired in accordance with Table 4.1 in Sect. 4.9 of this manual.

In this mode of operation the following generator functions are controlled from the receiver.

(i) Band-stop filters - selected by receiver CHANNEL SELECTOR push-buttons and switched out when receiver ZERO button is depressed.

(ii) NOISE ON/OFF - controlled by receiver GEN NOISE OFF switch.

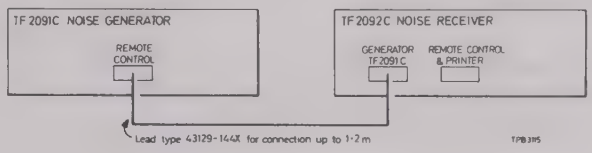

TF 2091C NOISE GENERATOR
REMOTE CONTROL
TF 2092C NOISE RECEIVER
GENERATOR TF 2091C
REMOTE CONTROL & PRINTER
Lead type 43129-144X for connection up to 1·2 m
TPB 395

Fig. 2.3 Generator and receiver interconnection

NOTE The generator REMOTE CONTROL push-button is not depressed for this mode of operation; a link in the receiver multi-way connector automatically establishes remote control and immobilizes the relevant generator front panel controls.

2.4.4 Receiver connections to printer

The receiver may be connected to any printer capable of accepting 8 or more columns of b.c.d. parallel input data at t.t.l. levels and operating from a print command pulse of 15 to 60 ms duration. The printer should preferably be capable of printing in both red and black. If it is intended also to use the printer with Control Unit TK 2085, it should have 16 column capacity and, preferably, a remote line feed facility.

A suggested format for the printout is shown in Fig. 2.4. The > symbol in column one, which is available on many printers, appears when the receiver is used to control the generator. This facility may be omitted if an 8 column printer is used. It is suggested that the receiver out of range warning signal is used to give printout in red.

Printers providing the above facilities include the following :

Manufacturer	Country of origin	Model number
GMT	UK	301-P16
GMT	UK	301-P16 (H1)
GMT	UK	303-P16 (rack mounting)
GMT	UK	304-P16
Roxburgh Electronics	UK	RP10-16
Roxburgh Electronics	UK	RP19-16 (rack mounting)
Anadex	USA	DP650A-21
General Radio	USA	1785-9701
General Radio	USA	1785-9702 (rack mounting)

The code/character relationship for these printers is listed in Table 4.2 of Sect. 4.10.1 of this manual.

Other printers which give slightly different character formats but are still suitable include the following :

Manufacturer	Country of origin	Model number
Anadex	USA	DP500-18
Fluke	USA	2010A-01

The pin numbering scheme for connecting the receiver to the printer is described in Sect. 4.10 of this manual. The receiver must be fitted with a program board for printer operation (see Sect. 2.1.2 for type number) and a 36-way plug is supplied for wiring to the printer connecting lead. GMT printer type 301-P16 (H1) is supplied ready for connection to the receiver and is available through Marconi Instruments under the order code 59999-704T.

Print command and receiver out of range signals are available from the receiver at positive or complementary logic levels and accept either a positive or a complementary printer busy signal. The logic sense is accommodated by patching of links on the programme board and the procedure is described in Sect. 4.8 of this manual.

The print command signal is available in either single shot or repetitive mode. These modes are fully described in Sect. 4.10.2 of this manual and alteration of mode is accommodated by program board patching (see Sect. 4.8).

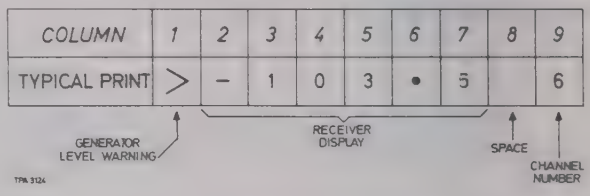


Fig. 2.4 Suggested printout format

2.4.5 Generator and receiver control from Control Unit TK 2085

The control unit provides control of all remote facilities of both the generator and receiver. Level stepping over a preset range in adjustable increments and cycling through a selected number of measuring channels may be initiated manually or remotely and the control unit provides printout information of generator level, receiver display, channel number and various warning signals. The method of interconnection is shown in Fig. 2.5. Detailed operating procedures and connection requirements are described in the TK 2085 instruction manual.

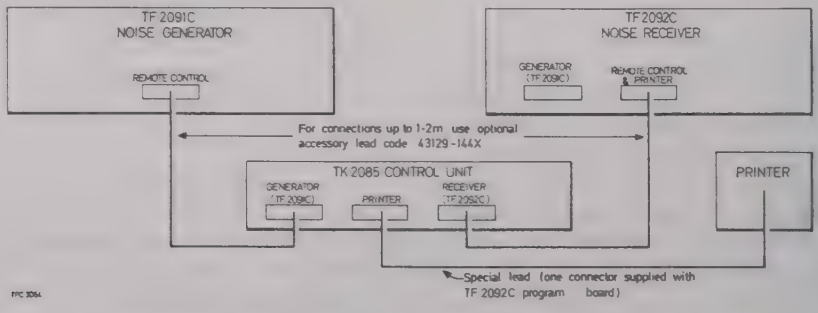


Fig. 2.5 Control unit connections

2.4.6 Remote control of generator and receiver

The general method of connection is shown in Fig. 2.6. A detailed description of the various signal lines to and from both the generator and receiver is given in Sect. 4.11 of this manual.

With the generator and receiver connected as shown and both set to the REMOTE CONTROL mode, the following functions may be remotely controlled.

Generator : Select band-limiting filters
Select band-stop filters
Band-stop filters in/out
Noise on/off
Send level in 0.1 dB steps (including sign)

Receiver : Select set zero
Select 1 pW/channel
Print trigger
Select measuring channel

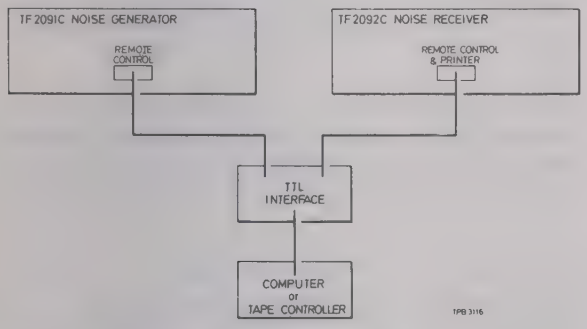


Fig. 2.6 General connection method for remote control operation

In addition to the receiver display information already described in Sect. 2.4.4 a number of warning/control signals are sent back to the controlling system. These include generator level warning, receiver out of range, n.p.r. mode selected and receiver in balanced state (see Sect. 4.11 for full description).

The only generator front panel control not immobilized in the remote control mode is the SET ZERO control. This may be used to standardize the generator against a standard milliwatt test set where optimum accuracy is required without altering the digital setting of the remotely controlled send level (see Sect. 2.19.10).

Major functions of the receiver which are not remotely controllable include only the transmission level attenuator and selection of measuring units. In both these cases it is assumed that the necessary arithmetic manipulations will be written into the controlling software where changes of transmission level or measuring unit occur during the test sequence.

2.5 CONTROLS

2.5.1 Generator

(1) SUPPLY switch. AC power supply ON/OFF switch. Pilot lamp indicates that mains transformer is energized, i.e. the supply fuse is intact.

(2) NOISE ON/OFF switch. Switches off the noise output. The lamp lights to indicate noise is off. Switch is biased away from the lower OFF position for temporary interruption of noise output.

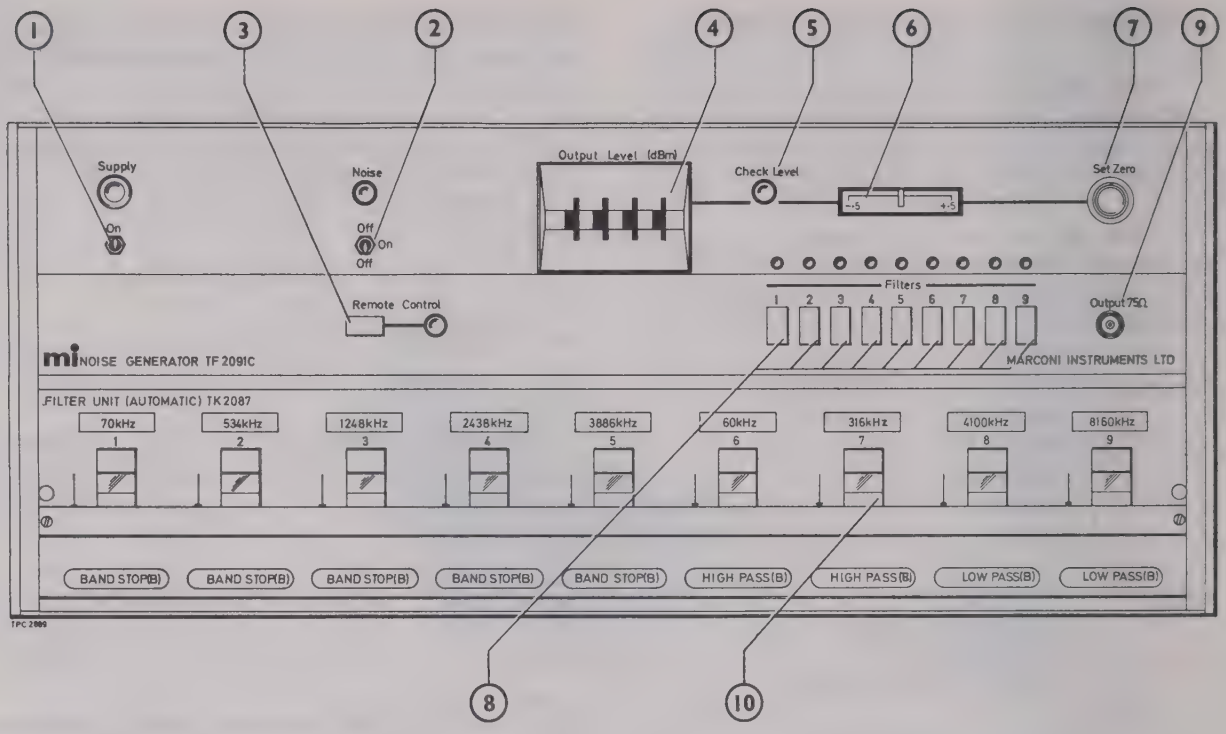
(3) REMOTE CONTROL push-button. Transfers control of all front panel controls except SET ZERO and SUPPLY to t.t.l. lines applied to REMOTE CONTROL rear multi-way connector. Front panel controls are inoperative in REMOTE CONTROL mode which is indicated by the lamp adjacent to the REMOTE CONTROL switch.

(4) OUTPUT LEVEL (dBm) thumbwheel switches. Set the output power of the generator within the range -59.9 to +19.9 dBm in 0.1 dB steps.

(5) CHECK LEVEL warning lamp. Lamp lights when output level is set to an unattainable level, e.g. > +19.9 dBm or too high a level on low channel capacities.

(6) METER. Indicates output level over range -0.5 to +0.5 dB relative to setting of OUTPUT LEVEL (dBm) switches. Meter reading is adjusted by means of SET ZERO control (see (7) below). OUTPUT LEVEL (dBm) switches are calibrated when METER indicates zero. Correct operation of a.l.c. is indicated by changes of meter indication less than ±0.1 dB when changing level or switching filters.

(7) SET ZERO control. Adjusts noise output level over the range indicated by the METER (see (6) above). May be used to provide small offsets when calibrating output using a standard milliwatt test set (see Sect. 2.19.10) or when compensating for band-stop filter stop band insertion loss (see Sect. 2.19.9).



(8) FILTERS push-buttons. Select the required band-stop filters fitted in positions 1 to 5 of the TK 2087 Filter Unit and the required band-limiting filters fitted in positions 7 to 9. Push-button number 6 may select either a band-stop or a band-limiting filter. Filters selected are indicated by the corresponding lamp above the FILTERS push-buttons.

NOTE. FILTERS push-buttons and REMOTE CONTROL of filter selection are only operative when the generator is fitted with Automatic Filter Unit TK 2087. When Manual Filter Unit TK 2087/1 is fitted, filter selection is by the rocker switches on the filter front panels only.

(9) OUTPUT socket. BNC socket, 75 Ω output impedance.

(10) FILTERS. High-pass and low-pass filters determine the bandwidth of the noise output and are fitted in positions 7 to 9. Band-stop filters used to provide the noise measuring channels are fitted in positions 1 to 5. Position 6 may house a band-stop or a band-limiting filter.

2.5.2 Receiver

(1) SUPPLY switch. AC power supply ON/OFF switch. Pilot lamp indicates that mains transformer is energized, i.e. the supply fuse is intact.

(2) INPUT socket. BNC socket, 75 Ω input impedance.

(3) GEN NOISE OFF switch. Switches off generator noise output when generator is remotely controlled from receiver (as described in Sect. 2.4.3).

(4) INPUT LEVEL HIGH and LOW lamps. Lamps light when input signal is outside the balance range of the receiver.

(5) TRANSMISSION LEVEL (-dBr) thumbwheel switches. On channel power measurements these switches offset the readout to provide measurement relative to the zero transmission level point (see Sect. 2.18 measuring units). Thumbwheel switches are variable in 1 dB steps over the range -49 dBr to 0 dBr.

(6) REMOTE CONTROL push-button. Transfers control of front panel controls numbers (14), (15) and (18) to t.t.l. lines applied to REMOTE CONTROL & PRINTER rear multi-way socket. REMOTE CONTROL mode is indicated by lamp adjacent to REMOTE CONTROL switch.

(7) DISPLAY. $2\frac{1}{2}$ digit l.e.d. display with polarity indication and illuminated measurement units as selected by push-buttons (8), (9) and (10) and TRANSMISSION LEVEL (-dBr) switches.

(8) NPR push-button. Selects receiver measurement in units of noise power ratio (for definition see Sect. 2.18.9).

(9) CHANNEL POWER push-buttons. Select receiver measurement in decibels of power per 3100 Hz bandwidth relative to one milliwatt or one picowatt (for definitions see Sect. 2.18.1).

(10) WEIGHTING push-buttons. Select receiver channel power measurement with PSOPHOMETRIC or C-MESSAGE weighting (for definitions see Sects. 2.18.3 and 2.18.7).

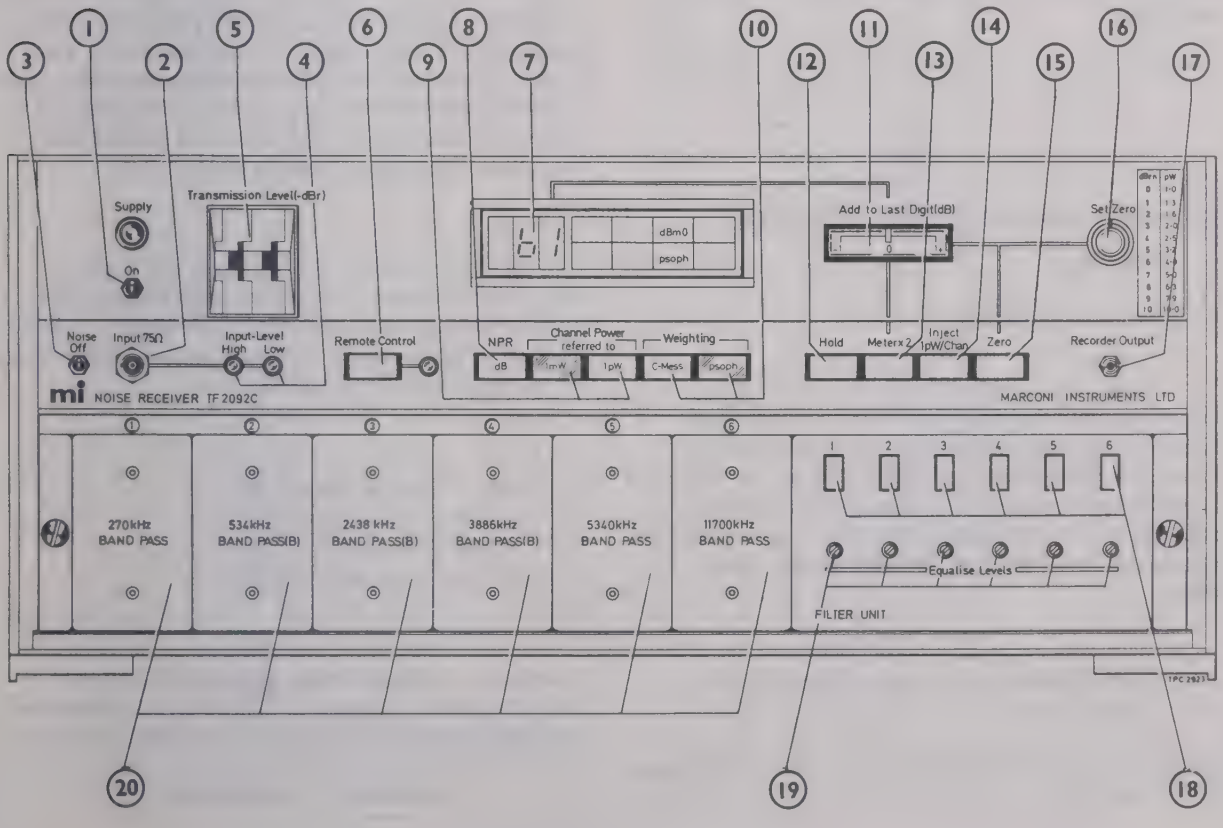
(11) METER : ADD TO LAST DIGIT (dB). Centre zero meter with a range of ±2.5 dB normally used for interpolating between 1 dB steps on display. Also used in conjunction with controls (12) and (13) for monitoring variations in receiver input level over range up to ±5 dB.

(12) HOLD push-button. Disables the auto-balancing action of the receiver thus holding the input attenuator at a fixed value. Allows the meter or recorder output to be used for analogue monitoring.

(13) METER x2 push-button. Changes the METER sensitivity to the range ±5 dB. Used in conjunction with (12) for analogue monitoring and for measurement in the range below -120 dBm per channel.

(14) INJECT 1 pW/CHANNEL push-button. Applies the internal standard noise source to the receiver input whilst maintaining 75 Ω termination for the system under test. Used for receiver self checking (see Sect. 2.20).

(15) ZERO push-button. Zeros display against receiver input signal in NPR mode or against internal standard noise source in CHANNEL POWER modes. Also removes band-stop filters when generator is remotely controlled from receiver (see Sect. 2.4.3).



⑯ SET ZERO control. Used in conjunction with meter to set indication to 0 dB when ZERO push-button is depressed.

⑰ RECORDER OUTPUT jack. Accepts a 2-pole telephone plug for connection to an external chart recorder. Used in conjunction with the HOLD push-button provides a range 'linear in dB' from -5 to +10 dB with respect to the METER centre zero.

⑱ CHANNEL SELECTOR push-buttons. Select the required measurement channel by switching in the appropriate band-pass filter and local oscillator. Also select the appropriate band-stop filter in the generator when remotely controlled from receiver (see Sect. 2.4.3).

⑲ EQUALIZE LEVEL presets. Enable all measuring channels to be set to the same sensitivity (see Sect. 2.8).

⑳ FILTERS. Band-pass filters in conjunction with local oscillator boards fitted internally (see Sect. 2.2.3) determine the measuring channel frequencies, which must coincide with the band-stop filter frequencies of the generator. Lamps above the filters indicate the measuring channel selected.

2.6 INTERPRETATION OF RECEIVER DISPLAY

2.6.1 Analogue display

The meter scale is marked in 0.5 dB divisions over the range ±2.5 dB. When used normally in conjunction with the digital display it will remain within the range -0.2 dB to +0.8 dB except when the digital display is zero in which case the meter will read within the range ±0.8 dB. The meter will only read outside these ranges when

(i) HOLD button is depressed (see (12) of Sect. 2.5.2).

(ii) Receiver INPUT LEVEL HIGH or LOW lamps are on.

The meter reading is always added to the digital display reading irrespective of the display sign as shown in the following examples.

Digital display	Meter reading	Measurement result
+100		+100.5
-100		-100.5
0		+0.5
0		-0.5
+100		+101.5*
-100		-101.5*

* only occurs if HOLD button is depressed or when receiver INPUT LEVEL LOW lamp is on.

2.6.2 Digital display and measuring units

The digital display has a maximum of 3 digits in steps of 1 dB with a maximum capacity of 159 together with minus sign. The panel to the right of this display contains 8 unit indicators which light in accordance with the measuring units selected as shown in Table 2.6. The units are defined and conversion formulas given in Sect. 2.18.

A table on the front panel (to the right of SET ZERO) allows conversion from dBrn to pW over the range 0 to 10 dBrn in 1 dB steps. This table allows immediate conversion to picowatt units from the digital display as follows.

dBrn	converts to pW
dBrn0	converts to pW0
dBrnp	converts to pWp
dBrn0p	converts to pW0p

Example : Digital display indicates 38 dBrn0p. Since 30 dBrn0 is equal to 10^3 pW0p and from the front panel table, 8 dBrn0p = 6.3 pW0p, we have

38 dBrn0p = 6300 pW0p

Table 2.6

Measuring units display panel

NPR	CHANNEL POWER referred to		WEIGHTING		TRANSMISSION LEVEL (-dBr) setting	Units display	Unit description
	1 mW	1 pW	C-MESS	PSOPH			
IN	OUT	OUT	OUT	OUT	INOPERATIVE	dB	Noise power ratio in decibels.
OUT	IN	OUT	OUT	OUT	ZERO	dBm	Channel power in dB relative to 1 mW.
OUT	IN	OUT	OUT	OUT	NON ZERO	dBm0	Channel power, dB rel. 1 mW referred to zero transmission level point.
OUT	IN	OUT	OUT	IN	ZERO	dBm psoph	dBm psophometrically weighted.
OUT	IN	OUT	OUT	IN	NON ZERO	dBm0 psoph	dBm0 psophometrically weighted.
OUT	OUT	IN	OUT	OUT	ZERO	dBrn	Channel power in dB relative to 1 pW (reference noise).
OUT	OUT	IN	OUT	OUT	NON ZERO	dBrn0	dBrn referred to zero transmission level point.
OUT	OUT	IN	OUT	IN	ZERO	dBrn psoph	dBrn psophometrically weighted.
OUT	OUT	IN	OUT	IN	NON ZERO	dBrn0 psoph	dBrn0 psophometrically weighted.
OUT	OUT	IN	IN	OUT	ZERO	dBrnC	dBrn with C-message weighting.
OUT	OUT	IN	IN	OUT	NON ZERO	dBrnC0	dBrn0 with C-message weighting.

NOTE (i) If both weighting buttons are depressed inadvertently, dBm units are selected for channel power referred to 1 mW. For channel power referred to 1 pW, dBrnC units are selected.

(ii) dBm0 and dBm0 psoph are equal to signal-to-noise ratio if the minus sign is ignored (see Sect. 2.18.10).

2.7 SETTING UP THE GENERATOR

The generator must be fitted with a filter unit containing band-limiting and band-stop filters - see Sect. 4.4 for method of fitting. If the generator is to be remotely controlled, as described in Sect. 2.4, Programmable Filter Unit TK 2087 is required. If manual operation only is required, Manual Filter Unit TK 2087/1 may be fitted.

The output of the generator should be terminated in 75 Ω when the instrument is being set up. Normally the system under test will provide this termination.

(1) Set the NOISE ON/OFF switch to ON and check that the associated lamp goes out. Check that the CHECK LEVEL warning lamp is out (this lamp will light if the filter unit is not pushed fully home).

(2) Switch in a high-pass and a low-pass filter to limit the generator output to the baseband of the system under test as shown in Tables 2.1 to 2.3. If the programmable filter unit is fitted, check that the lamps associated with the appropriate FILTERS push-buttons are lit. Do not use more than one high-pass and one low-pass filter at a time.

(3) Switch out all band-stop filters.

(4) Check that the meter indicates zero and, if not, adjust the SET ZERO control (see Note below).

(5) Set the required loading level on the OUTPUT LEVEL (dBm) thumbwheel switches. For testing of complete f.d.m. systems conventional loading levels are recommended by the CCIR. Calculation of the conventional load is described in Sect. 2.7.1.

NOTE. If optimum accuracy is required as described in Sect. 2.19.9 the generator may be standardized against a standard milliwatt test set using the following procedure immediately following (3) above.

(6) Set OUTPUT LEVEL (dBm) switches to 0 dBm and connect generator OUTPUT socket to standard milliwatt test set.

(7) Adjust SET ZERO control to give a reading of 0 dBm on the standard milliwatt test set.

(8) Continue with step (5) above.

2.7.1 Calculating the conventional loading level

The conventional loading level is defined by the CCITT in Recommendation G.223 and recommended by the CCIR in Recommendations 399-2 and 482. Conventional loading levels for commonly encountered channel capacities are listed in Table 2.7, the generator being set to the level of column 4.

Table 2.7

Level of the conventional load

1	2	3	4
Number of telephone channels	Relative power level at point T' (dBr)	Level of the conventional load (dBm0)	Nominal power level of the test signal at point T' (dBm)
60	−36	6·1	−29·9
120	−36	7·3	−28·7
300	−36	9·8	−26·2
600	−36 −33	12·8	−23·2 −20·2
960	−36 −33	14·8	−21·2 −18·2
1260	−33	16·0	−17·0
1800	−33	17·5	−15·5
2700	−33	19·3	−13·7

For other channel capacities the mean power of the conventional load (P) may be calculated from the following formulae where N is the number of telephone channels provided within the f.d.m. baseband.

$\overline{P} = -15 + 10 \log_{10} N$ dBm0 for $N \geqslant 240$ (1)

$\overline{P} = -1 + 4 \log_{10} N$ dBm0 for $12 \leqslant N < 240$ (2)

NOTE. These levels simulate the mean power of speech plus signalling currents, etc., transmitted over the system during the busy hour. Where a significant proportion of the baseband is used for v.f. telegraphy or data transmission other formulae will apply.

Example : 792 channels capacity with baseband input at a -33 dBr transmission level point.

Generator output level = $(-15 + 10 \log_{10} 792) - 33$

-19.0 dBm

2.8 SETTING UP THE RECEIVER

The receiver must be fitted with Filter Unit TK 2086 containing band-pass filters and local oscillator boards coincident in frequency with the band-stop filters fitted in the generator and located under corresponding measuring channel numbers. Sects. 4.5 and 4.6 describe the method of fixing.

Before commencing a series of measurements it is recommended that the receiver sensitivity is checked on each measuring channel to ensure that the EQUALIZE LEVEL presets are correctly adjusted.

(1) Depress the CHANNEL POWER referred to 1 mW button, release the WEIGHTING buttons and check that the dBm units light. Release the REMOTE CONTROL button and all four meter buttons.

(2) Select the lowest required measuring channel by depressing the corresponding CHANNEL SELECTOR button and check that the lamp above the band-pass filter lights.

(3) Depress the ZERO button and when the meter has settled, adjust the SET ZERO control for 0 on the meter.

(4) Depress the HOLD button to disable the auto-balancing action and switch through the required measuring channels checking that the meter continues to indicate 0.

(5) Release the ZERO and HOLD buttons. The receiver is now ready to take measurements in either NPR or CHANNEL POWER units.

If step (4) above indicates that the receiver sensitivity is not equalized across the measuring channels and comparative measurements between channels are required without the necessity of re-zeroing on each channel, the EQUALIZE LEVEL presets should be adjusted as described in Sect. 2.8.1 below.

2.8.1 Adjusting EQUALIZE LEVEL presets

(1) Depress the CHANNEL POWER referred to 1 mW button, release the WEIGHTING buttons and check that the dBm units light. Release the REMOTE CONTROL button and all four meter buttons.

(2) Select the lowest required measuring channel by depressing the corresponding CHANNEL SELECTOR button and check that the lamp above the band-pass filter lights.

(3) Turn all EQUALIZE LEVEL presets fully clockwise and turn the SET ZERO control mid-way.

(4) Depress the SET ZERO button and, when the meter has settled readjust the SET ZERO control for 0 on the meter.

(5) Depress the HOLD button and the METER x2 button. Do not release the ZERO button.

(6) Switch through the required measuring channels by depressing the corresponding CHANNEL SELECTOR buttons and select the channel giving the lowest meter reading. Release the HOLD button and readjust the SET ZERO control to restore the meter reading to 0. Depress the HOLD button again.

(7) Depress each CHANNEL SELECTOR button in turn and adjust the corresponding EQUALIZE LEVEL preset to return the meter reading to 0.

(8) Release the METER x2 button and repeat step (7) making minor adjustments if necessary.

(9) Release the ZERO and HOLD buttons. The receiver is now ready to take measurements in either NPR or CHANNEL POWER units.

NOTE. This procedure compensates for the differing insertion losses of different band-pass filter types. Readjustment should not normally be necessary unless the filter complement of the particular filter unit is altered. Do not attempt to set up the equalization when the OSCILLATOR OUTPUT socket at the rear of the instrument is connected to an external load e.g. oscilloscope input. See also Sect. 4.15.6.

2.8.2 Compensating for system baseband frequency response

Where the system under test has frequency response irregularities across its baseband and n.p.r. measurements are to be made with optimum accuracy without re-zeroing on every measuring channel, the EQUALIZE LEVEL presets may be adjusted to compensate for these irregularities.

(1) Connect the generator, set up as described in Sect. 2.7, for the baseband input of the system under test.

(2) Connect the receiver to the baseband output of the system under test.

(3) Ensure that all band-stop filters are out and depress the NPR button on the receiver.

(4) Carry out steps (2) to (8) of Sect. 2.8.1.

(5) Release the ZERO and HOLD buttons. The receiver is now ready to take measurements in n.p.r. units with system baseband frequency response automatically compensated for by the receiver.

NOTE. The receiver should not be used to measure in units of channel power when adjusted as described above. If measurement is required in channel power on such systems the normal adjustment procedure of Sect. 2.8.1 should be used.

2.9 MEASUREMENT IN UNITS OF NOISE POWER RATIO

The generator and receiver should be set up as described in Sects. 2.7 and 2.8. Noise power ratio is defined in Sect. 2.18.9 and factors affecting measurement accuracy are described in Sect. 2.19.

(1) Connect the generator and receiver to the baseband input and output of the system under test.

(2) Switch all generator band-stop filters out.

(3) Select the required measuring channel by depressing the appropriate CHANNEL SELECTOR button and check that the lamp above the band-pass filter lights.

(4) Depress the NPR button and check that the dB units light.

(5) Depress the ZERO button and ensure that the other three meter buttons are released. When the meter reading has settled, adjust the SET ZERO control to give a meter reading of 0.

(6) Release the ZERO button and check that the digital display indicates 0. The receiver is now set to the n.p.r. reference level.

(7) Switch in the appropriate generator band-stop filter.

(8) Note the n.p.r. when the display has settled. The n.p.r. is read from the digital display and meter as described in Sect. 2.6.

NOTES : (i) If the generator is remotely controlled from the receiver - see Sect. 2.4.3 - steps (2) and (7) are carried out automatically.

(ii) If a series of n.p.r's are to be measured on one measuring channel, steps (5) and (6) may be omitted if individual level increments are $\leqslant$ 19 dB since the receiver will automatically re-zero when the band-stop filter is switched out and the generator level changed.

(iii) If a series of n.p.r's are to be measured at a single noise loading level across the measuring channels, steps (5) and (6) may be omitted when switching to the second and subsequent channels provided the receiver is equalized (see Sect. 2.8.1). With the generator remotely controlled from the receiver (see Sect. 2.4.3), only steps (3) and (8) are necessary on the second and sub-sequent channels.

2.10 MEASUREMENT IN UNITS OF CHANNEL POWER OR SIGNAL-TO-NOISE RATIO

The generator and receiver should be set up as described in Sects. 2.7 and 2.8. Channel power units are defined in Sect. 2.18 and selection of units is described in Sect. 2.6.3. Factors affecting measurement accuracy are described in Sect. 2.19. To measure the noise in a measuring channel with the band-stop filter switched in use the procedure below. If measurement is required without band-stop filters, i.e., baseband flatness, see Sect. 2.11. If measurement is required with noise off, i.e., basic noise measurement, see Sect. 2.12.

(1) Connect the generator and receiver to the baseband input and output of the system under test.

(2) Switch all generator band-stop filters out.

(3) Select the required measuring channel by depressing the appropriate CHANNEL SELECTOR button and check that the lamp above the band-pass filter lights.

(4) Depress the required CHANNEL POWER and WEIGHTING buttons (as described in Sect. 2.6.3) and check that the corresponding units light.

(5) Set the TRANSMISSION LEVEL (-dBr) switches to the transmission level of the baseband output point if measurement is required referred to the zero transmission level point as described in Sects. 2.18.4 and 2.18.5. The units displayed should now have a '0' suffix. If measurement is required in absolute units set the TRANSMISSION LEVEL (-dBr) switches to 0.

(6) Depress the ZERO button in order to standardize the receiver against the internal 1 pW/channel standard. When the meter has settled adjust the SET ZERO control to give a meter reading of 0.

(7) Release the ZERO button.

(8) Switch in the appropriate generator band-stop filter.

(9) Note the measured value when the display has settled by reading both the digital display and the meter as described in Sect. 2.6.

Example.

Digital display = -58 dBm
Meter reading = +0.5 dB
Channel power = -(58 + 0.5) = -58.5 dBm.

NOTES : (i) If the generator is remotely controlled from the receiver steps (2) and (8) are carried out automatically.

(ii) After initially standardizing, steps (6) and (7) may be omitted when changing generator noise loading level and also when changing measuring channel provided the receiver has been equalized (see Sect. 2.8.1). With the generator remotely controlled from the receiver only steps (3) and (9) are necessary after initial standardizing when changing level or measuring channel.

(iii) For measurement of signal-to-noise ratio, set to dBm0 or dBm0 psoph in step (4) and ignore the minus sign in step (9).

2.11 MEASUREMENT OF BASEBAND FREQUENCY RESPONSE

Baseband frequency response may be measured at the frequencies of the measuring channels by selecting appropriate channel power units in the receiver and switching out the generator band-stop filters. The procedure is as Sect. 2.10 with step (8) omitted. After initial standardizing the measurement is made by repeating steps (3) and (9) only, provided the receiver is equalized (see Sect. 2.8.1).

NOTE. Since band-stop filters are automatically selected by the CHANNEL SELECTOR buttons when controlling the generator from the receiver, the connecting cable (if fitted) must be disconnected for this measurement.

2.12 MEASUREMENT OF BASIC NOISE

The total noise appearing within a noise measuring channel at the output of the system under test will comprise both basic (or idle) noise and intermodulation noise. Basic system noise is independent of noise loading level and is measured with the generator noise output switched off. It may be measured in units of channel power (see Sect. 2.12.1 below) or as a basic noise power ratio or baseband intrinsic noise ratio (see Sect. 2.12.2 below).

2.12.1 Basic noise measured in channel power units

The measurement procedure is as described in Sect. 2.10 with the addition of the following step immediately after step (8) of Sect. 2.10.

(8a) Set NOISE ON/OFF switch to OFF on the generator or if remotely controlled from receiver, use the receiver NOISE ON/OFF switch.

2.12.2 Basic noise measured as a noise power ratio

Basic noise power ratio or baseband intrinsic noise ratio is defined in Sect. 2.18.11. The measurement procedure is as described in Sect. 2.9 with the generator set to the conventional loading level (see Sect. 2.7.1) and the addition of the following step immediately after step (7) of Sect. 2.9.

(7a) Set the NOISE ON/OFF switch to OFF on the generator or, if remotely controlled from the receiver, use the receiver NOISE ON/OFF switch.

2.13 OUT-OF-BAND MEASUREMENT

This application is described in Sect. 2.3.5. The receiver should be fitted with band-pass filters and local oscillators conforming to CCIR Recommendations 398-3 or 481 and a corresponding band-stop filter should be located at the baseband input of the system under test to minimize incoming noise within the measuring channel bandwidth. Recommended filter frequencies are shown in Tables 2.4 and 2.5.

(1) Connect the receiver to a suitable baseband output monitoring point on the system.

(2) Carry out steps (3) to (7) of Sect. 2.10.

(3) Note the measured value of noise in the out-of-band measuring channel.

NOTE. For continuous monitoring over a range of up to 15 dB it may be convenient to connect a chart recorder to the receiver RECORDER OUTPUT jack as described in Sect. 2.15.

For continuous recording over a wider range the receiver may be connected to a printer as described in Sect. 2.4.4. Where the receiver is required to cycle between a 'below-band' and an 'above-band' measuring channel, Control Unit TK 2085 may be used as described in Sect. 2.4.5.

2.14 MEASUREMENT OF COMPONENTS WITH VERY LOW INTERMODULATION LEVELS

The application of noise loading to system components is described in Sect. 2.3.4. Where the n.p.r. of the unit under-test approaches the inherent n.p.r. of the OA 2090C White Noise Test Set a correction is necessary. The measurement technique is described below.

(1) Measure the n.p.r. of the unit under test as described in Sect. 2.9. Let this be n.p.r. (1).

(2) With the generator set to the same level as in step (1) above, measure the inherent n.p.r. of the test set as described in Sect. 2.20.2. Let this be n.p.r. (2).

The correction factor is taken from Fig. 2.7 as illustrated by the following example.

Example :

Measured n.p.r. of unit under test:
n.p.r. (1) = 68 dB.

Inherent n.p.r. of test set:
n.p.r. (2) = 72.5 dB.

From Fig. 2.7 the difference between n.p.r. (2) and n.p.r. (1) of 4.5 dB gives a correction factor of 2 dB.

Hence actual n.p.r. of unit under test is n.p.r. (1) + correction factor of 2 dB = 70 dB.

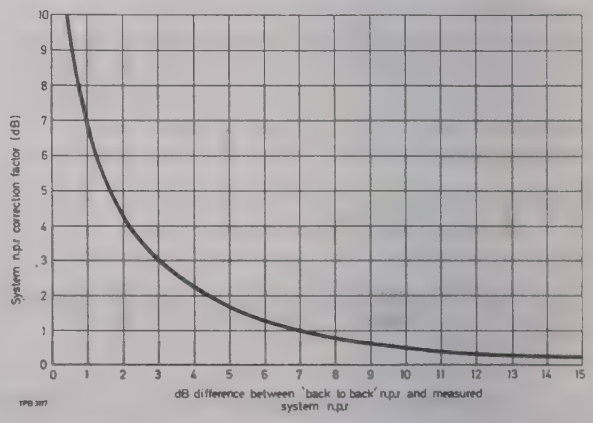


Fig. 2.7 System n.p.r. correction factor when system n.p.r. is close to 'back-to-back' n.p.r. of white noise test set

2.15 USE OF RECORDER OUTPUT

The RECORDER OUTPUT jack provides a voltage of 0 to 3 V e.m.f. corresponding with -5 dB to +10 dB relative to the 0 point on the receiver meter. The output is 'linear in dB', i.e. 200 mV/dB and a maximum current of 15 mA is available. The procedure for using this facility is as follows.

(1) Connect a suitable chart recorder to the RECORDER OUTPUT jack.

(2) Set up the receiver as described in steps (3) to (7) of Sect. 2.10.

(3) Connect the generator directly to the receiver and adjust the generator level until the receiver displays a suitable level to use as the chart recorder 0 dB point.

NOTE. For very low levels, it may be necessary to switch in the generator band-stop filter.

(4) Depress the HOLD button and disconnect the generator.

(5) Connect the generator (if required) and receiver to the input and output of the system under test.

2.16 PLOTTING AN NPR OR CHANNEL POWER CURVE

It is common practice to measure the performance of a system over a range of noise loading levels, e.g., from -10 dB to +6 dB relative to the conventional loading level (see Sect. 2.7.1), and to present the results in the form of an n.p.r. curve or channel power curve. Typical examples are shown in Figs. 2.8 and 2.9.

(1) Set the generator output level to the required number of dB below the conventional loading level.

(2) Carry out steps (1) to (8) of Sect. 2.9 or steps (1) to (9) of Sect. 2.10 taking account of notes (i) and (ii) of either section.

(3) Repeat (2) over the required range of loading levels.

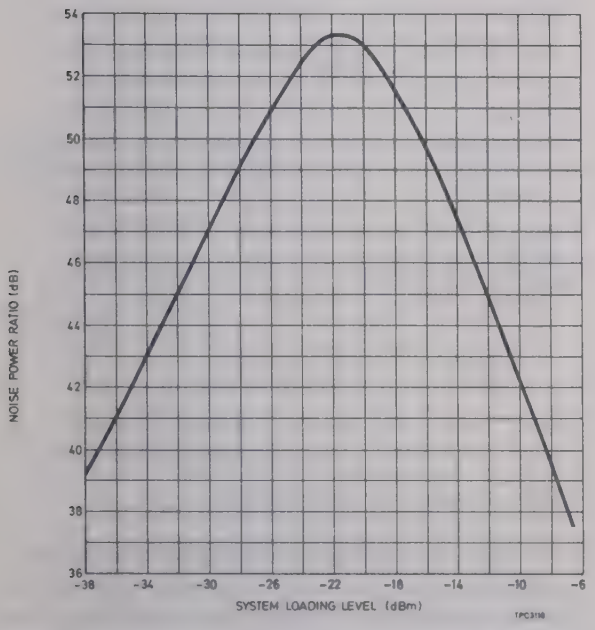


Fig. 2.8 A typical noise power ratio curve

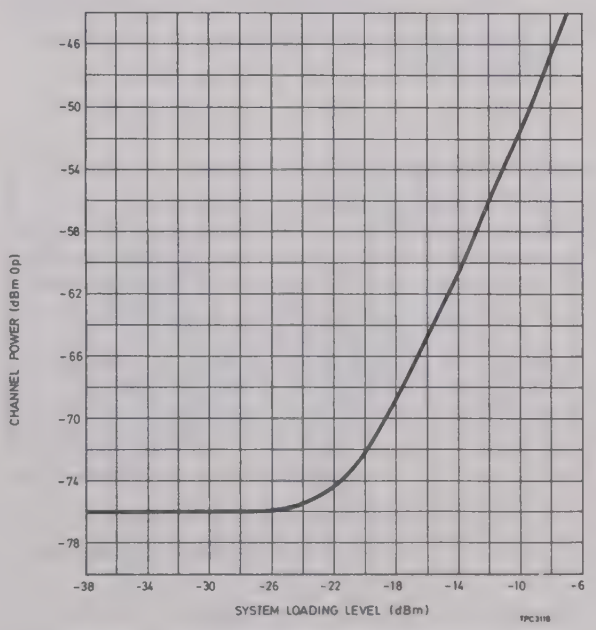


Fig. 2.9 A typical channel power curve

2.17 PLOTTING A PATH LOSS CURVE FOR A RADIO RELAY SYSTEM

During factory testing of a radio relay system the path attenuation may be simulated by inserting attenuators in the individual hops. The performance of the system under fading conditions may then be evaluated by varying the attenuation in one hop about the nominal value.

2.17.1 Path loss dependent basic noise

(1) Carry out the measurement sequence of Sect. 2.12.1 over the required range of single hop path attenuations. Note that after the first measurement no adjustment of either the generator or the receiver is necessary.

(2) Plot the measured basic channel power against path attenuation as shown, for example, in Fig. 2.10.

2.17.2 Path loss dependent total noise

(1) Carry out the measurement sequence of Sect. 2.10, with the generator set to the conventional loading level, over the required range of single hop path attenuations. Note that after the first measurement no adjustment of either the generator or the receiver is necessary.

(2) Plot the measured total channel noise power against path attenuation as shown, for example, in Fig. 2.12.

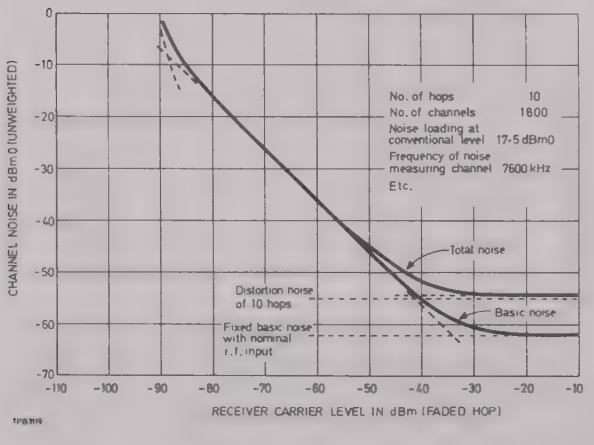


Fig. 2.10 Examples of total noise and basic noise curves for a simulated radio-relay system when one hop only is faded

2.18 MEASURING UNITS AND WEIGHTING, DEFINITIONS AND CONVERSION FORMULAS

2.18.1 Decibels above 1 mW, picowatts and decibels above reference noise

The 'standard test tone' in a telephone system is universally accepted as a level of one milliwatt at the 'zero transmission level point' (see Sect. 2.18.4). It is common practice, therefore, to specify other signals in decibels referred to one milliwatt abbreviated dBm.

i.e. 0 dBm = 1 mW

Interference noise in telephone systems, on the other hand, is invariably at levels well below 1 mW, and such noise is frequently expressed in picowatts (10^{-12} W).

i.e. 1 pW = 10^{-12} W = -90 dBm

A level of one picowatt is sometimes referred to as reference noise and levels specified in decibels referred to one picowatt are denoted by dBrn.

i.e. 0 dBrn = 1 pW = -90 dBm

hence dBrn = dBm + 90 ..... 1.

2.18.2 Units of power density

When individual telephone channels are assembled into a multichannel baseband, it is necessary to distinguish between total baseband power and power per unit bandwidth. The unit bandwidth is most commonly 3100 Hz but 1000 Hz and 4000 Hz are sometimes used. Per channel power density assumes a bandwidth of 3100 Hz and dBm per channel is related to other bandwidths as follows :

dBm/4 kHz = dBm/channel + 1 .... 2.
dBm/kHz = dBm/channel - 5 .... 3.

2.18.3 Psophometric weighting

Research has been carried out to determine the degree of transmission impairment caused by noise interfering with speech in a telephone channel. A large number of listening tests were made with different frequency tones introduced as interference.

The degree of interference was detemined by comparing the power of each interfering tone with the power of an 800 Hz tone which listeners subjectively felt created a similar degree of interference. The CCITT weighting curve derived from these tests is known as commercial telephone circuit psophometer weighting (or psophometric weighting). It is shown in Fig. 2.11. Noise measuring sets weighted in this way (psophometers) indicate channel noise levels more in accord with the actual interfering effect of noise than would a set with a flat frequency response.

When a flat noise in the telephone channel bandwidth of 300 to 3400 Hz is passed through a psophometric filter its power level is reduced by 2.5 dB as shown by the hatching of Fig. 2.11. Notice that the 0 dB reference is at 800 Hz with +1 dB at 1000 Hz returning to 0 dB at 1200 Hz. Below 800 Hz and above 1200 Hz all frequencies are attenuated.

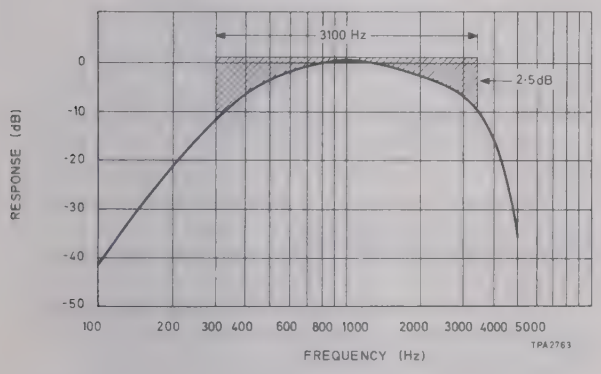


Fig. 2.11 Commercial telephone circuit psophometer weighting

Noise measured with a psophometer is designated by the suffix p. Thus dBm become dBmp and pW become pWp.

For flat noise in the band 300 to 3400 Hz the following relationship applies.

dBmp = dBm - 2.5 ..... 4.
pWp = pW x 0.56 ..... 5.

Note, however, that a 0 dBm 800 Hz tone measured by a psophometer will indicate 0 dBmp.

2.18.4 System level and the zero transmission level point

A multichannel telephone system may be both long and complex with many stages of gain and attenuation due to the transmission media, repeaters, multiplexers, demultiplexers etc. To state the power level of a signal measured in such a system has little meaning unless the gain or attenuation of that measurement point is also specified. System level of gain or attenuation at any particular point can only be specified if a reference level for the system is defined. Other points in the system may then be expressed in terms of decibels of gain or attenuation relative to this reference level.

In a telephone system, this reference point is designated the zero transmission level point, usually abbreviated zero TLP. It is the point in the system at which the standard test tone has an absolute power of 1 mW or 0 dBm. The zero TLP is often situated in the trunk exchange (toll office) at the transmit end of long haul systems.

2.18.5 Transmission level (dBr)

The level of any point in the system expressed in decibels relative to the zero TLP is referred to as the relative transmission level of that point. It is commonly designated by dBr although TLP is sometimes used. For example :

> A -33 dBr (or -33 TL) point in a system will be 33 dB below the zero transmission level point.

Since the standard test tone is 1 mW (= 0 dBm) at zero TLP the actual power of the standard test tone at any other point in the system when specified in dBm should be numerically equal to the transmission level of that point. For example, at a -10 dBr point the standard test tone should be -10 dBm. Any variation will signify that the system has excess gain or attenuation. It follows from the definition of dBr that the zero transmission level point has a level of 0 dBr or 0 TL.

2.18.6 Relative power level

It must be emphasized that dBr signifies the level of any physical point in the system. It is not a measure of power. If signal power is

measured at any point in the system in absolute terms (e.g. dBm), it may be related to nominal loading levels by expressing it relative to the transmission level at that same point. Power levels specified in this way are given the suffox 0.

Thus dBm is related to dBm0 as follows :

$$dBm0 = dBm - dBr \quad \ldots\ldots \quad 6.$$

The advantage of this suffix is that a power level expressed in dBm0 may be immediately related to nominal system loading levels without the necessity of also specifying the transmission level of the point at which it was measured. It follows from the definitions of zero TLP and dBr that the power of a signal measured at the zero transmission level point and expressed in dBm0 will be numerically equal to its absolute power in dBm. It is also evident that the standard test tone should be measured to be 0 dBm0 at every point in a system.

In addition to dBm0, the suffix 0 is used to indicate relative power in dBmp, pW and pWp. These become dBm0p, pW0 and pW0p.

2.18.7 C-message weighting

Current telephone hand sets in use in North America differ somewhat in their frequency response from those which gave rise to the psophometric weighting curve described in Sect. 2.18.3. The equivalent weighting curve, known as C-message weighting is shown in Fig. 2.12. Flat noise in the bandwidth 300 to 3400 Hz is attenuated 1.5 dB when passed through a filter of this characteristic as shown in the figure.

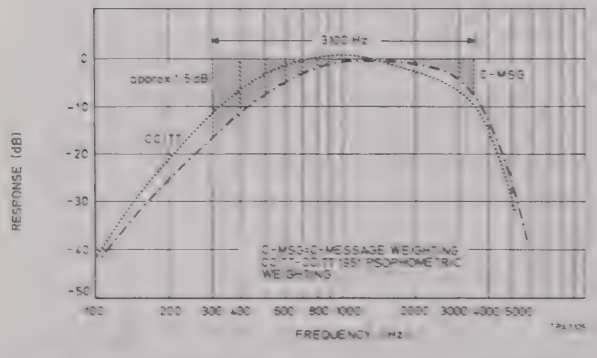


Fig. 2.12 C-message and psophometric weighting curves

Comparison of C-message and psophometric weighting shows C-message to have a poorer response below 1 kHz and a superior response above 1 kHz. The 0 dB reference frequency for C-message weighting is 1000 Hz whereas that for psophometric weighting is 800 Hz.

Noise measured with a C-message weighted noise measuring set is designated by the suffix C and units of decibels above reference noise (1 pW) are always used with this form of weighting.

For flat noise in the bandwidth 300 to 3400 Hz the following relationship applies.

$$dBrnC = dBrn - 1.5 \quad \ldots\ldots \quad 7.$$

2.18.8 Conversion factors dBrnC to dBm and pW

Combining the equations of 2.18.1, 2.18.3 and 2.18.7 gives the following conversion factors.

$$dBrnC = dBm + 88.5 \quad \ldots\ldots\ldots \quad 8.$$

$$dBrnC = dBmp + 91 \quad \ldots\ldots\ldots \quad 9.$$

$$dBrnC = 10 \log_{10} pW - 1.5 \quad \ldots \quad 10.$$

$$dBrnC = 10 \log_{10} pWp + 1 \quad \ldots\ldots \quad 11.$$

2.18.9 Noise power ratio

The most common unit of measurement in white noise testing is noise power ratio (n.p.r.) which is defined as follows.

NPR is the decibel ratio of the noise level in a measuring channel with the baseband fully noise loaded .... to .... the level in that channel with all of the baseband noise loaded except the measuring channel.

Measurement of n.p.r. is described in Sect. 2.9.

2.18.10 Signal-to-noise ratio

Specifying the noise in a test channel as a noise power ratio provides a relative indication of interference. An alternative is to express the noise in decibels relative to a specified absolute signal level in the test channel. Signal-to-noise ratio (s/n) is defined as follows.

S/N is the decibel ratio of the level of the standard test tone (0 dBm0) .... to .... the noise in a 3100 Hz bandwidth within the test channel.

Signal-to-noise ratio is therefore numerically equal to the per channel noise expressed in dBm0 with the sign inverted. For example, a noise level of -44 dBm0/channel is equivalent to a s/n ratio of 44 dB.

Hence s/n = -dBm0.

Signal-to-noise ratio is commonly measured with psophometric weighting, in which case :-

S/N (psoph.) = -dBm0p

Measurement of s/n is described in Sect. 2.10.

2.18.11 Baseband intrinsic noise ratio or basic noise power ratio

It is common practise to measure basic (or idle) noise separately as well as measuring the combined effect of basic plus intermodulation noise present within the non-linear region of the system. Basic noise may be specified in any of the units already described in this section. It is sometimes, however, specified as a noise power ratio relative to the conventional loading level. This 'basic noise power ratio' is often called baseband intrinsic noise ratio, abbreviated b.i.n.r., and is defined as follows.

BINR is the decibel ratio of noise in a test channel with the baseband loaded at the conventional level .... to .... noise in the test channel with all noise loading removed.

Measurement of basic noise is described in Sect. 2.12.

2.18.12 Conversion of n.p.r. to s/n

Since Noise Receiver TF 2092C provides a readout directly in n.p.r. (dB) or s/n (-dBm0 or -dBm0p) it is not normally necessary to convert between the two units.

However, equation 12 below specifies the relationship which is derived in the White Noise Book.

$$S/N = NPR + 10 \log_{10} \frac{\Delta f}{3.1} - P + W \quad \ldots\ 12.$$

Where Δf is the bandwidth of the baseband in kHz
P is the noise loading level in dBm0
W is the weighting factor in decibels
(e.g. 2.5 for psophometric weighting)

Where the baseband is loaded at the conventional level (see Sect. 2.7.1) equation 12 may be approximated (within ±0.2 dB) by the following, where N is the nominal channel capacity of the system under test.

$$S/N = NPR + 16.3 + W \text{ for } N \geqslant 240 \quad \ldots\ 13.$$

$$S/N = NPR + 6 \log_{10} N + 2.1 + W$$
$$\text{for } 12 \leqslant N < 240 \quad \ldots\ 14.$$

2.19 FACTORS AFFECTING MEASUREMENT ACCURACY

2.19.1 Introduction to measurement accuracy

There are many factors contributing to the accuracy of n.p.r. measurement. They may, however, be separated into distinct areas. Firstly there are parameters which are a function of the noise generator and its band-limiting filters. Secondly accuracy will be affected by the parameters of the receiver. The third and most significant effect, however, is due to the width of the measuring channel and the way in which its contribution to n.p.r. error is altered by automatic level control in the generator. The loading level, order of distortion and use of pre-emphasis in the system, will all modify the error due to slot width. All these areas are discussed separately in this section which concludes with an example of n.p.r. error calculation which includes the effects of all factors described.

Before discussing these various contributory factors it is necessary to obtain a quantitative understanding of the shape of an n.p.r. curve. Only then can the effect upon error of the various factors be calculated both for the linear and the non-linear regions of the system under test.

2.19.2 The three regions of a noise loading curve

The noise loading curve may be thought of as comprising three separate regions. Firstly the linear region in which basic noise only contributes. Secondly the region around maximum n.p.r. where both basic and intermodulation noise contribute. Thirdly the non-linear region in which basic noise is insignificant and intermodulation noise predominates.

In the linear region an increase of 1 dB in loading level increases n.p.r. by 1 dB and the signal-to-noise ratio remains constant since only basic noise is measured. At the point of maximum n.p.r. basic and intermodulation noise are related by the predominant order of system distortion, γ, as follows.

Basic noise power = (γ - 1) x intermodulation noise power.

In the non-linear region an increase of 1 dB in loading level decreases the n.p.r. by (γ - 1) dB and the signal-to-noise ratio by γ dB. It is therefore evident that, whereas errors in the generator send level will have a direct effect on n.p.r. accuracy within the linear region of the loading curve, their effect will be weighted (γ - 1) times in contributing to n.p.r. accuracy within the non-linear region.

NOTE. A more detailed discussion of this subject is given in Chapter 9 of the White Noise Book.

2.19.3 Noise generator parameters

There are two main parameters of the generated noise which can contribute to n.p.r. error. Firstly any uncertainty in the total noise power will effect n.p.r. accuracy as described in the previous sub-section. Total noise power level accuracy is a function of the accuracy of the generator's power monitor and its output attenuator. The overall effect is taken as the root sum square (r.s.s.) of these two parameters in the example of Sect. 2.19.10. The accuracy of cut-off frequency of the band-limiting filters will effect the overall bandwidth and therefore the per channel loading. This factor is not considered further since it is insignificant with 'B' filters. Frequency response of the generated noise across the band will have a direct effect on n.p.r. accuracy since the reference level with the measuring slot 'out' will vary directly with the flatness of the noise. It will be remembered that an 'A' filter pair must be flat within 1 dB, a 'B' filter pair within 0.2 dB. The n.p.r. error due to the noise generator (excluding 'slot width' factor) is therefore as follows :

Linear region :

$$e_g = \pm(e_{ag}^2 + e_{mg}^2 + e_f^2)^{\frac{1}{2}} \quad \ldots\ldots\ldots\ldots 1.$$

Non-linear region :

$$e_g = \pm\left[(\gamma - 1)^2 (e_{ag}^2 + e_{mg}^2) + e_f^2\right]^{\frac{1}{2}} \quad \ldots 2.$$

where e_g = n.p.r. error due to generator
e_{ag} = error in attenuator setting
e_{mg} = error in power monitor indication
e_f = frequency response over baseband.

2.19.4 Noise receiver parameters

Noise Receiver TF 2092C uses band-pass filters to minimize receiver intermodulation and this potential source of error is insignificant. Since an automatic 'slideback' technique is used to restore the receiver meter to within ±0.5 dB of its initial reference level the only important source of error is due to the accuracy of the receiver input attenuator. The error in n.p.r. due to the receiver will therefore be as follows.

$$e_r = e_{ar} \quad \ldots\ldots\ldots\ldots 3.$$

where e_r = n.p.r. error due to receiver
e_{ar} = error in attenuator setting.

2.19.5 Effect of slot width

When a band-stop filter is switched into the noise baseband, the insertion loss of its stop band removes power. It is clear that, if components within the stop band of the filter are contributing to intermodulation products also within the stop band, then removing those fundamental components by switching in the band-stop filter will reduce the level of measured i.p. below the correct value. An optimistic n.p.r. will result. It may further be supposed that the wider the filter the worse this effect. The actual error will also be a function of the position of the slot within the baseband and the order of distortion predominating. The use of system pre-emphasis may be expected to exaggerate this effect for a slot near the top of the baseband (see Sect. 2.19.7).

It is for these reasons that the 'B' recommendations specify very much narrower filters and that CCITT (G228) state that filters should be inserted one at a time to avoid compounding the problem. A quantitative analysis of this general problem has been carried out and has yielded the correction factors of Tables 2.8 and 2.9.

Slot width and baseband factors

Analysis of the problem has shown that the reduction in i.p. (n.p.r. error) is a function of three basic variables. The slot width expressed as a ratio to the baseband width is designated 'a'. The error is also a function of the bandwidth factor 'b' which is defined as the ratio of the lowest frequency of the baseband to the baseband width. These two variables are illustrated in Fig. 2.13 for a baseband between f_1 and f_2 with a slot of width δf. Previous work had indicated that errors were a function of 'a' only. The inclusion of 'b' has precluded the simple plotting of n.p.r. error against 'a' and has necessitated the preparation of Tables 2.8 and 2.9. These have been calculated for 25 common baseband capacities using actual values of 'a' and 'b'. For each baseband both 'A' and 'B' filters have been considered in the bottom and top slots. The complexity of derivation for various values of the third variable, the order of distortion 'γ', has prevented the work being extended to include a middle slot. Since, however, most systems use pre-emphasis, it is the top slot which is of major interest.

It must be emphasized that these tables apply to the region of the n.p.r. curve where non-linear distortion is predominant. No correction factor for slot width is necessary in the linear n.p.r. region since noise is due to thermal effects only and the measurement is independent of slot width.

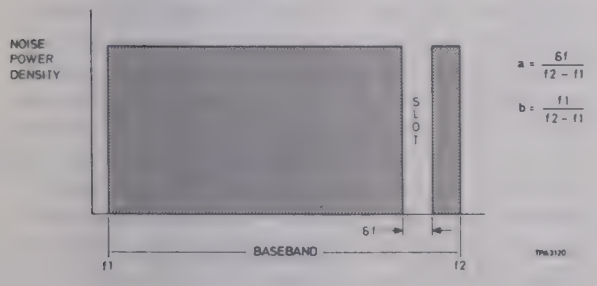


Fig. 2.13 Slot width and baseband factors

2.19.6 Effect of automatic level control

TF 2091C Noise Generator is fitted with automatic level control (a.l.c.) which maintains total output power constant when switching band-stop filters. The provision of a.l.c. not only compensates for the stop band insertion loss of the filter but also restores the power lost in the filter's pass band equalizer. Such equalizers are necessary on many 'B' band-stop filters to achieve the very low pass band ripple required by the latest recommendations.

The effect of a.l.c. therefore is to maintain constant total power (c.t.p.). The power density in the pass band is therefore increased by a.l.c. action so there is the possibility that a.l.c. may over compensate for the intermodulation products lost due to filter insertion since all other fundamentals are increased. Keeping these fundamentals at a constant level (i.e. constant power density) is illustrated in comparison with constant total power in Fig. 2.14.

Tables 2.8 and 2.9 show corrections to be applied for both the constant power density (c.p.d.) and the constant total power (c.t.p.) cases. It can be seen that for systems with 3rd order distortion, the n.p.r. error is minimized if total power is held constant. That is, the a.l.c. automatically provides best accuracy. In the case of 2nd order distortion, normal use of a.l.c. gives best accuracy in the bottom slot for flat systems and is better as often as it is worse in the top slot. With pre-emphasis, although constant noise power density gives smaller errors in the bottom slot, the normal use of a.l.c. gives errors less than or equal to 0.2 dB above 120 channels and 0.1 dB above 300 channels. For the top slot again there is no advantage in readjustment to maintain constant power density. The bottom slot case in 4th order distortion systems gives similar orders of error and since these are less than or equal to 0.2 dB above 120 channels and 0.1 dB above 300 channels again it is recommended that normal a.l.c. be used. The top slot shows, however, an advantage in reducing the level after insertion of the filter by an amount equal to its stop band insertion loss, thus maintaining constant power density. It should be noted, however, that using 'B' filters at 900 channels and above the error due to normal a.l.c. operation is 0.1 dB or less so readjustment is unnecessary.

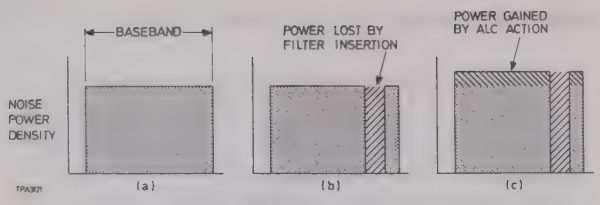


Fig. 2.14 Constant power density and constant total power. ALC makes the total power in (c) equal to that in (a)

On balance therefore it is shown that a.l.c. in maintaining constant total baseband power, gives improved accuracy in many cases and it is recommended that, in general, normal operation of a.l.c. is used. Where in specific cases better accuracy can be obtained with constant power density then the level can be reduced after filter insertion by an amount equal to the filter's stop band insertion loss. Tables of stop band insertion loss are given in Sect. 2.19.9.

2.19.7 Effect of pre-emphasis

The pre-emphasis network recommended by CCIR is shown in Fig. 2.15. Channels near the bottom of the baseband are attenuated by 4 dB whereas those near the top have 4 dB pre-emphasis. The 0 dB point occurs approximately 60% along the baseband. The equation would make calculation of slot width error for pre-emphasized basebands untenable. A simplified curve has therefore been used in the slot width error calculations. This curve is of the form exp k (f/f_{max}). With k = 1.842 the curve is coincident with the CCIR curve at the baseband extremes but deviates by 1 dB at the centre of the baseband. This form has been used in other work on pre-emphasized systems and yielded results close to those observed in practice. It is compared with the CCIR curve in Fig. 2.15.

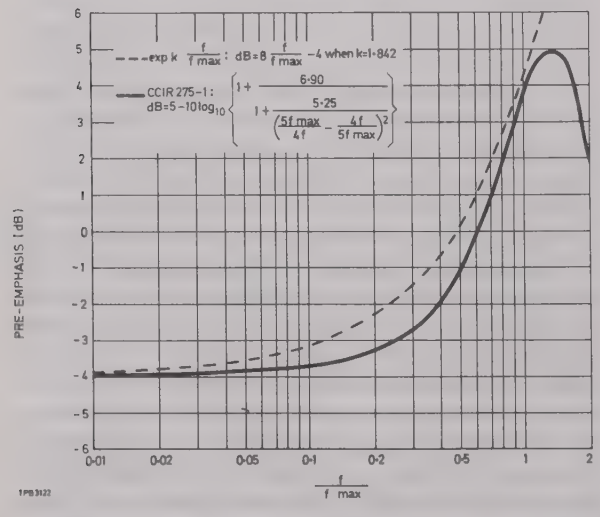


Fig. 2.15 Pre-emphasis curve to CCIR Recommendation 275-1 compared with exponential approximation

2.19.8 Corrections due to slot width

Table 2.9 lists the correction factors for bottom slots and Table 2.8 those for top slots. Each table gives corrections for both flat and pre-emphasized systems. In each table both 'A' and 'B' filters are considered with constant total power (normal a.l.c.) and constant power density for 2nd and 3rd order distortion. In the flat cases only, 4th order is also listed. The more common channel capacities are shown together with their band limits and the corrections are expressed to the nearest 0.1 dB. A dash signifies an error less than 0.05 dB whereas a gap indicates that filters do not exist for that channel capacity. Corrections should be added to the measured n.p.r. Comparison between the 'A' and 'B' type filter corrections shows the improved accuracy possible with the narrower 'B' filters and emphasizes the necessity for selecting only one band-stop filter at a time. As an example, the correction factor for a 'B' filter in the top slot of a 2700 channel system with pre-emphasis and 3rd order distortion is only -0.1 dB whereas even with a.l.c. the 'A' filter correction is -2.5 dB.

2.19.9 Band-stop filter insertion loss

The effects of automatic level control on n.p.r. accuracy were discussed in Sect. 2.19.6 and Tables 2.8 and 2.9 list slot width correction factors for the two cases of constant total power and constant power density. The former case is achieved with normal a.l.c. operation. However, where constant power density is to be maintained for optimum accuracy, the output noise power must be reduced by an amount equal to the stop band insertion loss of the filter. Table 2.10 lists the insertion losses of 'B' type filters for a variety of channel capacities. As may be expected at 3886 kHz and above 'B' filters have insignificant insertion loss.

Table 2.8

NPR corrections (dB) due to slot width which should be added to the measured n.p.r.

TOP SLOT																	
		Flat system										4 dB pre-emphasis					
		2nd order distortion predominant				3rd order distortion predominant				4th order distortion predominant				2nd order distortion predominant			
System capacity (channels)	Limits of baseband (kHz)	'A' filters		'B' filters		'A' filters		'B' filters		'A' filters		'B' filters		'A' filters		'B' filters	
		CTP	CPD	CTP	CPD	CTP	CPD	CTP	CPD	CTP	CPD	CTP	CPD	CTP	CPD	CTP	CPD
12	12–60	2,7	—	1,6	—	−0,8	−5,0	−0,5	−2,9	4,8	−0,7	2,7	−0,4	2,7	—	1,6	—
24	12–108	1,7	−0,4	0,8	—	−0,3	−3,3	−0,1	−1,3	3,1	−0,9	1,3	−0,2	1,5	−0,5	0,8	—
36	12–156	1,3	−1,2			−0,4	−4,1			3,2	−1,8			0,9	−1,5		
48	12–204	0,9	−0,9			−0,2	−3,0			2,4	−1,4			0,8	−1,1		
60	12–252	0,7	−0,3	0,4	—	−0,1	−1,6	—	−0,6	1,4	−0,6	0,6	−0,1	0,7	−0,3	0,4	—
60	60–300	1,6	—	0,6	—	−0,5	−2,9	−0,2	−1,1	2,8	−0,4	1,0	−0,2	1,6	—	0,6	—
72	12–300	0,6	−0,7	0,5	—	−0,1	−2,1	—	−0,8	1,7	−1,0	0,8	−0,2	0,5	−0,8	0,5	—
96	12–408			0,4	−0,1			—	−0,8			0,7	−0,3			0,4	−0,1
120	60–552	1,2	—	0,5	—	−0,2	−1,9	−0,1	−0,9	2,0	−0,4	0,9	−0,2	1,2	—	0,5	—
132	12–552			0,3	−0,2			—	−0,8			0,7	−0,3			0,3	−0,2
192	12–804			0,2	−0,2			—	−0,7			0,6	−0,4			0,2	−0,3
252	12–1052	0,2	−0,8	0,2	−0,3	—	−1,5	—	−0,7	1,0	−1,0	0,5	−0,4	0,1	−0,9	0,2	−0,3
300	60–1300	0,7	−0,4	0,5	—	−0,1	−1,6	—	−0,8	1,4	−0,7	0,8	−0,2	0,6	−0,4	0,5	—
432	12–1796			0,1	−0,4			—	−0,7			0,5	−0,5			0,1	−0,4
600	60–2600	0,4	−0,4	0,3	−0,1	−0,1	−1,3	—	−0,6	1,0	−0,6	0,6	−0,2	0,3	−0,5	0,3	−0,1
612	12–2600			0,1	0,3			—	−0,6			0,4	−0,4			0,1	−0,3
792	12–3284			0,1	−0,4			—	−0,7			0,4	−0,5			—	−0,4
900	316–4100	0,9	−0,1	0,1	—	−0,1	−1,6	—	−0,1	1,6	−0,4	0,1	—	0,9	−0,1	0,1	—
960	60–4100	0,2	−0,7	0,1	—	−0,1	−1,4	—	−0,1	1,0	−0,8	0,1	—	0,2	−0,7	0,1	—
972	12–4100			—	—			—	−0,1			0,1	—			—	—
1200	316–5600	0,7	−0,1	—	—	−0,1	−1,3	—	−0,1	1,3	−0,4	0,1	—	0,7	−0,1	—	—
1260	60–5600	0,2	−0,6	—	—	—	−1,3	—	−0,1	0,9	−0,8	0,1	—	0,1	−0,7	—	—
1800	316–8160	0,6	−0,6	—	—	−0,1	−1,9	—	−0,1	1,5	−0,9	0,1	—	0,5	−0,7	—	—
1872	12–8160			—	—			—	−0,1			—	—			—	—
2700	316–12 360	0,4	−0,8	—	—	−0,1	−2,0	—	—	1,4	−1,0	—	—	0,3	−0,9	—	—

CTP Constant total power (normal a.l.c. operation).	CPD Constant power density.	'—' signifies correction less than 0,05 dB.

Table 2.9

NPR corrections (dB) due to slot width which should be added to the measured n.p.r.

BOTTOM SLOT																	
		Flat system										4 dB pre-emphasis					
		2nd order distortion predominant				3rd order distortion predominant				4th order distortion predominant				2nd order distortion predominant			
System capacity (channels)	Limits of baseband (kHz)	'A' filters		'B' filters		'A' filters		'B' filters		'A' filters		'B' filters		'A' filters		'B' filters	
		CTP	CPD	CTP	CPD	CTP	CPD	CTP	CPD	CTP	CPD	CTP	CPD	CTP	CPD	CTP	CPD
12	12–60	0,3	−1,3	0,3	−1,7	−1,3	−3,6	−1,4	−4,5	1,6	−1,6	2,0	−2,1	1,2	−0,4	1,5	−0,5
24	12–108	0,3	0,5	0,4	0,6	0,6	−1,7	−0,8	−2,2	0,9	0,6	0,9	0,8	0,7	0,1	0,9	−0,1
36	12–156	0,2	−0,3			−0,4	−1,1			0,6	−0,4			0,5	—		
48	12–204	0,2	−0,2			−0,2	−0,8			0,4	−0,3			0,3	—		
60	12–252	0,1	−0,2	0,2	−0,2	−0,2	−0,6	−0,2	−0,8	0,3	−0,2	0,4	−0,3	0,3	—	0,3	—
60	60–300	0,2	−0,6	0,2	−0,7	−0,8	−2,1	−0,8	−2,2	0,9	−0,8	1,0	−0,9	0,7	−0,2	0,8	−0,2
72	12–300	0,1	−0,1	0,1	−0,2	−0,1	−0,5	−0,3	−0,6	0,3	−0,2	0,4	−0,3	0,2	—	0,3	—
96	12–408			0,1	−0,1			−0,1	−0,5			0,3	−0,2			0,2	—
120	60–552	0,2	−0,2	0,2	−0,3	−0,3	−0,9	−0,3	−1,0	0,5	−0,3	0,5	−0,4	0,4	—	0,4	—
132	12–552			0,1	−0,1			−0,1	−0,3			0,2	−0,1			0,2	—
192	12–804			0,1	−0,1			−0,1	−0,2			0,1	−0,1			0,1	—
252	12–1052	—	—	—	—	—	−0,1	—	−0,2	0,1	−0,1	0,1	−0,1	0,1	—	0,1	—
300	60–1300	0,1	−0,1	0,1	−0,1	−0,1	−0,3	−0,1	−0,4	0,2	−0,1	0,2	−0,1	0,2	—	0,2	—
432	12–1796			—	—			—	−0,1			0,1	—			—	—
600	60–2600	—	—	—	—	—	−0,2	—	−0,2	0,1	−0,1	0,1	−0,1	0,1	—	0,1	—
612	12–2600			—	—			—	−0,1			—	—			—	—
792	12–3284			—	—			—	−0,1			—	—			—	—
900	316–4100	0,1	−0,1	—	—	−0,1	−0,3	—	−0,2	0,1	−0,1	0,1	−0,1	0,1	—	0,1	—
960	60–4100	—	—	—	—	—	−0,1	—	−0,1	0,1	—	0,1	—	—	—	—	—
972	12–4100			—	—			—	—			—	—			—	—
1200	316–5600	—	—	—	—	−0,1	−0,2	—	−0,1	0,1	−0,1	0,1	—	0,1	—	—	—
1260	60–5600	—	—	—	—	—	−0,1	—	−0,1	—	—	—	—	—	—	—	—
1800	316–8160	—	—	—	—	—	−0,1	—	−0,1	0,1	−0,1	—	—	0,1	—	—	—
1872	12–8160			—	—			—	—			—	—			—	—
2700	316–12 360	—	—	—	—	—	−0,1	—	—	0,1	—	—	—	—	—	—	—

Table 2.10

Stop band insertion losses of 'B' type filters

System capacity (channels)		24	60	60	96	120	132	192	252	300	432	600	612	792	900	960	972	1200	1260	1800	1872	2700
Baseband (kHz)		12-108	12-252	60-300	12-108	60-552	12-552	12-804	12-1052	60-1296	12-1796	60-2600	12-2600	12-3284	316-4100	60-4100	12-4100	316-5600	60-5600	316-8160	12-8160	316-12360
Band-stop filter Part of Set TK	Frequency (kHz)																					
2094/9	16	0.40	0.15	—	0.10	—	0.05	0.05	0.05	—	0	—	0	0	—	—	0	—	—	—	—	—
2094/10	40	0.30	0.10	—	0.05	—	0.05	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2094/11	56	0.30	0.10	—	0.05	—	0.05	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2094	70	—	0.45	0.40	0.25	0.20	0.20	0.15	0.10	0.10	0.05	0.05	0.05	0.05	—	0.05	0.05	-	0	—	0	-
2094/12	98	0.30	0.15	0.15	0.10	0.05	0.05	0.05	0.05	0	—	—	—	—	—	—	—	—	—	—	—	—
2094/14	185	—	0.15	0.15	0.10	0.05	0.05	0.05	0.05	0.05	0	0	0	—	—	—	—	—	—	—	—	—
2094/15	240	—	0.15	0.15	0.10	0.10	0.05	0.05	0.05	0.05	0	0	0	—	—	—	—	—	—	—	—	—
2094/1	270	—	—	0.25	0.15	0.10	0.10	0.05	0.05	0.05	0.05	0	0	0	—	0	0	—	0	—	—	—
2094/16	394	—	—	—	0.15	0.15	0.15	0.10	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2094/2	534	—	—	—	—	0.25	0.25	0.15	0.10	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0	0
2094/19	770	—	—	—	—	—	—	0.20	0.15	0.10	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0	0	—	—	—
2094/20	1002	—	—	—	—	—	—	—	0.20	0.20	0.10	0.10	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0	0
2094/3	1248	—	—	—	—	—	—	—	—	0.20	0.15	0.10	0.10	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0	0
2094/17	1730	—	—	—	—	—	—	—	—	—	0.20	0.15	0.15	0.10	0.10	0.10	0.10	0.05	0.05	—	—	—
2094 4	2438	—	—	—	—	—	—	—	—	—	—	0.20	0.20	0.15	0.15	0.15	0.15	0.10	0.10	0.05	0.05	0.05
2094/18	3150	—	—	—	—	—	—	—	—	—	—	—	—	0.30	0.20	0.15	0.15	0.10	0.10	0.10	0.10	0.05

At 3886 kHz and above the insertion loss is negligible and no correction is required.

Table 2.11 lists minimum 'A' filter insertion losses based on the CCIR 399 formula for minimum 3 dB bandwidth (see Sect. 1.2). Individual filters may well exceed this minimum bandwidth by an amount which is significant. Where constant power density is to be maintained and the ultimate accuracy achieved with 'A' filters therefore, it is recommended that the filters 3 dB bandwidth be measured with a selective level measuring set. The reduction in power level (dB) is then given by

$$\text{Insertion loss (dB)} = 10 \log_{10} \frac{\delta f}{f_2 - f_1}$$

where δf = 3 dB bandwidth

$f_2 - f_1$ = bandwidth of baseband.

2.19.10 Overall measurement accuracy

The various factors contributing to overall n.p.r. accuracy may be combined to give the following equations for n.p.r. error - 'e_n'.

Linear region $$e_n = \pm \left[e_g^2 + e_r^2 \right]^{\frac{1}{2}} \quad \ldots\ldots\ldots 4.$$

Non-linear region $$e_n = \pm \left[e_g^2 + e_r^2 \right]^{\frac{1}{2}} + e_s \quad \ldots\ldots 5.$$

where e_s = slot width error from Tables 2.8 and 2.9 of Sect. 2.19.8 and e_g and e_r are as defined in Sects. 2.19.3 and 2.19.4.

Table 2.11

Minimum stop band insertion losses of 'A' type filters

System capacity (channels)		12	24	36	48	60	60	120	132	240	300	600	900	960	1200	1260	1800	2700
Baseband (kHz)		12-60	12-108	12-156	12-204	12-252	60-300	60-552	12-552	60-1052	60-1300	60-2660	316-4188	60-4028	316-5564	60-5564	316-8204	316-12388
Band-stop filter TM	Frequency (kHz)																	
7729	14	0.6	0.3	0.2	0.2	0.1	—	—	0	—	—	—	—	—	—	—	—	—
7729/21	27	1.0	0.5	0.3	0.3	0.2	—	—	0.1	—	—	—	—	—	—	—	—	—
7729/12	34	0.9	0.5	0.3	0.2	0.2	—	—	0.1	—	—	—	—	—	—	—	—	—
7729 1	40	1.0	0.5	0.4	0.3	0.2	—	—	0.1	—	—	—	—	—	—	—	—	—
7729-13	56	1.0	0.6	0.5	0.3	0.3	—	—	0.1	—	—	—	—	—	—	—	—	—
7729/2	70	—	0.8	0.5	0.4	0.3	0.3	0.2	0.1	0.1	0.1	0	—	0	—	0	—	—
7729 3	105	—	0.6	0.7	0.5	0.4	0.4	0.2	0.2	0.1	0.1	0	—	0	—	0	—	—
7729 4	185	—	—	—	0.6	0.4	0.4	0.2	0.2	0.1	0.1	0	—	0	—	0	—	—
7729.22	245	—	—	—	—	0.4	0.5	0.2	0.2	0.1	0.1	0	—	0	—	0	—	—
7729 5	270	—	—	—	—	—	0.5	0.3	0.2	0.1	0.1	0	—	0	—	0	—	—
7729/6	534	—	—	—	—	—	—	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0	0	0	0
7729 15	1002	—	—	—	—	—	—	—	—	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0	0
7729/7	1248	—	—	—	—	—	—	—	—	—	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0
7729/8	2438	—	—	—	—	—	—	—	—	—	—	0.3	0.2	0.2	0.1	0.1	0.1	0.1
7729/9	3886	—	—	—	—	—	—	—	—	—	—	—	0.3	0.3	0.2	0.2	0.2	0.1
7729/17	5340	—	—	—	—	—	—	—	—	—	—	—	—	—	0.3	0.3	0.2	0.1
7729/10	8002	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.3	0.2
7729/11	12150	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.3

Inserting equations 1 to 3 of these sections into equations 4 and 5 give :-

Linear region

$$e_n = \pm\left[e_{ag}^2 + e_{mg}^2 + e_f^2 + e_{ar}^2\right]^{\frac{1}{2}} \quad \ldots\ldots\ldots\ldots \quad 6.$$

Non-linear region

$$e_n = \pm\left[(\gamma-1)^2(e_{ag}^2 + e_{mg}^2) + e_f^2 + e_{ar}^2\right]^{\frac{1}{2}} + e_s \quad \ldots. \quad 7.$$

Example : To calculate the possible error in a 'top slot' n.p.r. of 60 dB for an 1800 channel system with pre-emphasis, 3rd order distortion predominant and a -20 dBm send level.

Source of error		Maximum error (dB)
generator attenuator,	e_{ag}	±0.2
generator monitor,	e_{mg}	±0.3
frequency response,	e_f	±0.5
receiver attenuator,	e_{ar}	±0.4

Slot width error - e_s - (1800 channels, top slot, pre-emphasis, 3rd order distortion, normal a.l.c., 'B' filters).

$$e_s = -0.1 \text{ dB}$$

Inserting these values in equations 6 and 7 gives :-

Linear region

maximum n.p.r. error = ±0.7 dB

Non-linear region

maximum n.p.r. error = -0.1 ±1.0 dB.

To obtain highest accuracy, the generator output may be standardized at 0 dB using a standard milliwatt test set. This makes e_{mg} insignificant and improves accuracy particularly in the non-linear region where e_{mg} is weighted $\gamma - 1$ times. In the above example, the maximum errors become :-

Linear region

maximum n.p.r. error = ±0.6 dB

Non-linear region

maximum n.p.r. error = -0.1 ±0.8 dB.

The factors affecting n.p.r. accuracy discussed in this section are independent of the corrections to be applied when system n.p.r. approaches the inherent n.p.r. of the white noise test set. In such cases, the corrections of Sect. 2.14 should be applied in addition to those described above.

2.20 SELF-CHECK PROCEDURES

2.20.1 Receiver self check

Set up the receiver as described in Sect. 2.8.

(1) Select the lowest measuring channel by depressing the appropriate CHANNEL SELECTOR button and check that the lamp above the band-pass filter lights.

(2) Set the TRANSMISSION LEVEL (-dBr) switches to 0, depress the CHANNEL POWER referred to 1 mW button and release the WEIGHTING buttons. Check that the dBm units light.

(3) Turn the SET ZERO control mid-way and depress the ZERO button ensuring that the other three meter buttons are released.

(4) When the meter reading has settled, bring it to 0 by means of the SET ZERO control.

(5) Release the ZERO button and depress the INJECT 1 pW/CHANNEL button.

(6) Check that the receiver indicates -90 dBm.

(7) Check that this readout is obtained on all required measuring channels by depressing the corresponding CHANNEL SELECTOR buttons.

(8) Now depress the CHANNEL POWER and WEIGHTING buttons as shown below and check that the corresponding readouts and units are displayed.

CHANNEL POWER referred to		WEIGHTING		READOUT (including meter)	Displayed units
1 mW	1 pW	PSOPH	C-MESS		
IN	OUT	IN	OUT	-92.5	dBm psoph
OUT	IN	OUT	OUT	0	dBrn
OUT	IN	IN	OUT	-2.5	dBrn psoph
OUT	IN	OUT	IN	-1.5	dBrnC

(9) Rotate the TRANSMISSION LEVEL (-dBr) switches and check that the readout changes in step.

(10) With the TRANSMISSION LEVEL (-dBr) switches set to -10 dBr depress the CHANNEL POWER and WEIGHTING buttons as shown below and check that the corresponding readouts and units are displayed.

CHANNEL POWER referred to		WEIGHTING		READOUT (including meter)	Displayed units
1 mW	1 pW	PSOPH	C-MESS		
IN	OUT	OUT	OUT	-80	dBm0
IN	OUT	IN	OUT	-82.5	dBm0 psoph
OUT	IN	OUT	OUT	10	dBrn0
OUT	IN	IN	OUT	7.5	dBrn0 psoph
OUT	IN	OUT	IN	8.5	dBrnC0

2.20.2 Back-to-back check of generator and receiver

The generator and receiver should be set up as described in Sects. 2.7 and 2.8.

(1) Connect the generator OUTPUT socket directly to the receiver INPUT socket.

(2) Set the generator OUTPUT LEVEL (dBm) switches to the conventional loading level as described in Sect. 2.7.1 assuming a zero transmission level e.g. +16 dBm for 1260 channels.

(3) Switch all generator band-stop filters out.

(4) Select the lowest required measuring channel by depressing the appropriate CHANNEL SELECTOR button.

(5) Depress the NPR button and check that the dB units light.

(6) Depress the ZERO button and ensure that the other three meter buttons are released. When the meter reading has settled, adjust the SET ZERO control to give a meter reading of 0.

(7) Release the ZERO button and check that the digital display indicates 0.

(8) Switch in the appropriate generator band-stop filter and check that the readout is 67 dB or greater.

(9) Repeat steps (3), (4) and (8) for all required measuring channels.

Chapter 3

Technical description

3.1 NOISE GENERATOR TF 2091C

Overall description

A Gaussian noise spectrum covering the frequency range from below 6 kHz to above 12.36 MHz is produced by the noise generator. After passing through a gain controlled amplifier the noise bandwidth is limited by a high-pass and a low-pass filter. These are followed by an output amplifier which has the additional capability of switching the noise off. A slot in the noise spectrum is then introduced by a band-stop filter and the signal passed via an attenuator to the OUTPUT socket.

Feedback is taken from between the band-stop filters and output attenuator and is then passed to a cascode amplifier. This supplies two feedback paths. One is taken to the output amplifier to stabilize the gain of the output stages. The second continues the main feedback loop via the level control attenuator (coarse), detector, level control attenuator (fine) and d.c. amplifier. The d.c. amplifier carries out three basic operations :

(i) giving a meter indication which interpolates between the steps of the OUTPUT LEVEL (dBm) indication,

(ii) controlling the gain control amplifier via the comparator, thereby completing the main feedback loop so as to maintain a level mean output power, regardless of filter switching,

(iii) switching on, via the limits comparator and interface controller, the CHECK LEVEL lamp in an out-of-range situation.

The interface control receives a number of stimuli as shown in Fig. 3.1 and thereby controls the appropriate functions such as local or remote control, band-limiting and band-stop filter selection and output level setting.

It also provides signals to light the indicator lamps associated with these functions.

Noise source : A1 - see Fig. 7.2

A noise diode, D1, is biased such that it produces a substantially flat random noise spectrum through the range 6 kHz to 13 MHz. The diode is reverse biased and a current flow of between 300 μA to 2 mA, controlled by R4 and R5, passes through it.

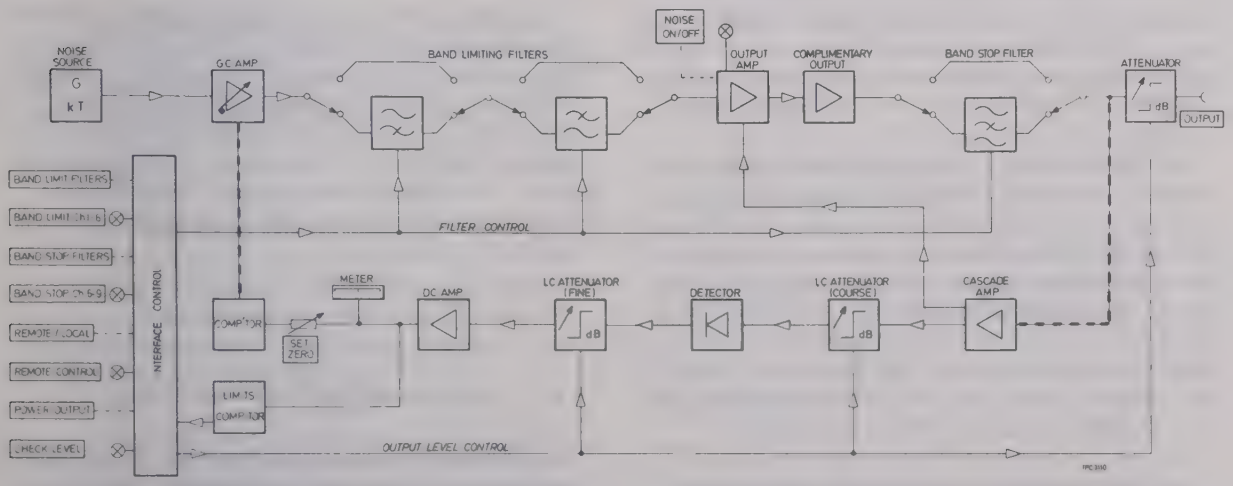


Fig. 3.1 Generator block diagram

TR2 and TR3 form a wide band feedback amplifier with R9 providing sufficient negative feedback for there to be a virtual earth at the base of TR3. Therefore there is no significant voltage swing, regardless of the current through TR2. C8 decouples R11 and R12 providing negative d.c. feedback via R7 and giving the whole stage a low output impedance.

TR4 acts as a voltage controlled resistor, and with R13 forms a variable gain stage, buffered by TR5. The gain of TR4 (and TR8) is determined by the output level from comparator IC1 which is controlled by the voltage from the SET ZERO potentiometer.

Another feedback amplifier, consisting of TR6 and TR7 includes a frequency equalization feedback network with gain control preset R16. This network compensates for the fall in output of the noise diode as the frequency increases. C16 is selected in calibration to match the individual noise diode. This stage feeds into the second gain controlled stage, which is identical to the first. This is followed by a third feedback amplifier, TR10 and TR11, and an emitter follower buffer stage, TR12 giving a 75 Ω output.

IC2 and IC3, which are fed from the meter, form a limits comparator with hysteresis, which operates the CHECK LEVEL lamp via TR14. The hysteresis effect is necessary to prevent erratic flashing of the CHECK LEVEL lamp, due to the varying level of the noise signal amplitude.

3.1.1 Output monitor: A3—see Fig. 7.2

The signal to the output attenuators (A4) is sampled by the output monitor, passing first into a cascode amplifier TR1 and TR2. C2, by altering the feedback around this stage, sets the frequency response. TR3 acts as a low impedance buffer.

Resistors R8 to R13 form the coarse level control attenuator. Frequency response is equalized by the inclusion of C8 and C24. The attenuator is relay controlled from the interface board, which switches relays A to D in or out; only one can be in circuit at any one time. Capacitors C9 to C13 short any r.f. component to earth, and suppress any spikes resulting from relay switch-off. Signal output from the coarse attenuator is fed via buffer amplifier TR4 to the detector.

The main constituents of the detector are IC1 and IC2 which are monolithic diode arrays, arranged as two matched bridges. Bridge (a) formed by IC1a2 and IC2a2 is used in the actual detection process. Positive and negative input voltages applied to pins 2 and 8 are developed across R18 and R17 respectively and, after smoothing, are fed to the d.c. amplifier IC3.

The second bridge compensates for the forward voltage drop across the 'a' bridge. The quiescent current through the two bridges is balanced by R21 so that under zero input signal conditions, the differential output voltage is nil.

The differential output is produced via R23 and R22. R22 is fed from the top of the 'b' bridge and meets R20 from the bottom of the 'a' bridge; the average voltage at the junction of these must therefore be zero, irrespective of the voltage at the centre of the bridges. Similarly R23 is fed from the bottom of the 'b' bridge and connects with R19, thereby causing a similar effect. These outputs are fed to IC3, which therefore has applied to it a differential voltage proportional to the average value of the input signal. The gain of IC3 is set by R27.

Both diode bridges are protected from switch-on transients by means of D10 and the diode between pins 11 and 12 of IC2a.

The output of IC3 is fed through R32, which is part of the fine level attenuator to d.c. amplifier IC4. Transistors TR5, TR6 and TR7 switch in the resistors according to the b.c.d. code from board A6. R44 is in the feedback circuit of IC4 and is similarly switched by TR8. Diodes D1, D2, D3 and D4 prevent the reverse breakdown of the base emitter junction of the transistors, and in the absence of a command signal, clamp the voltage close to earth.

Output from the attenuated signal via IC4 is compared with a reference voltage, derived by R46 and R47, and applied to meter M1. Diodes D5 and D6 protect the meter against overload. R49 is set so that the SET ZERO control has a symmetrical range of adjustment about the meter zero. The output from the SET ZERO control completes the feedback loop to the gain control amplifier on board A1.

3.1.2 Output amplifier: A2—see Fig. 7.3

From the band limit filters (AC1), the signal is passed into the wide band feedback amplifier formed by TR1 and TR2. This stage has a 75 Ω input impedance to match the filters.

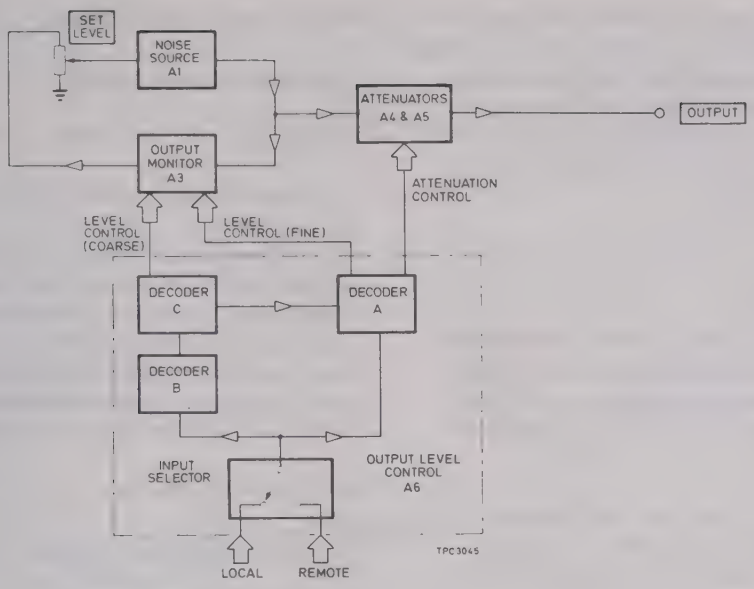


Fig. 3.2 Output level control arrangement

Output from the feedback amplifier is fed through an amplification and frequency compensation stage TR3 to another feedback amplifier, TR8. Thermistor TH1 with C29 in parallel in the feedback path ensure a level frequency response with varying temperature. TR7 forms a constant current load for TR8.

The output stage, T9 and T10, is a class B amplifier driven by TR8. D3 drops the voltage across the output stage to approximately 43 volts. Its output impedance of 39 Ω is made up to a nominal 75 Ω by the equalizer network in the filter tray (AC2).

The noise is switched off by taking pin 8 to the 5.2 V line. This action causes TR6 to conduct. When TR5 is cut off, the base of TR4 goes positive causing the voltage line to collapse.

3.1.3 Output attenuators: A4 and A5—see Fig. 7.3

Attenuation of the output signal is achieved by 8 relay operated 'T' pads, with a total range of 64 dB in 1 dB steps. The higher value pads contain a frequency compensating network.

The relay coils are driven from the interface board (A6) via gating circuits which cause the contact across the series arm to be closed when the contact in the shunt arm is open, and vice versa.

The attenuated signal, which has a range of +5 dBm to -59 dBm, is taken to the OUTPUT socket on the front panel.

3.1.4 Interface board (output level control): A6—see Fig. 7.5

Introduction

In principle the output level of the generator is determined by two factors :-

(a) the output of noise source A1 which is governed by the attenuation in the feedback path through output monitor A3 and

(b) the setting of attenuators A4 and A5.

These in turn are controlled by the local or remote level control signals acting via the logic interface of output level control board A6.

This arrangement is illustrated in Fig. 3.2 and the outline operation of the control board can be considered in three parts as follows :-

Input selector

This accepts a parallel b.c.d. input with polarity control signal from either the remote control socket or the local thumbwheel switches and provides a corresponding inverted output.

The control logic in each of the twelve input lines consists of a NOR gate preceded by two AND gates - one in the remote line and the other in the local line. One of the AND gates is enabled and the other inhibited by the lines from IC8b/2 and -a/2 whose state is determined by the setting of the REMOTE switch.

Coarse level control

The first part of this section, designated Decoder B in Fig. 3.2, provides coded signals corresponding to various settings of the Tens, Units and Decimal level controls, as shown by the notation on Fig. 7.5; for example,

T = 1 ('10' selected, with '20' and '40' lines off)
U = 5 ('5' selected, i.e. '4' and '1' lines on)
D = 0 (decimal '0' selected, i.e. all decimal lines off)

These coded outputs are then processed by Decoder C so as to control the 5, 10, 15 and 20 dBm steps in the output monitor, A3.

Attenuation control and fine level control

This section, designated Decoder A in Fig. 3.2, accepts signals from the input selector and from the coarse level control section. From these the appropriate signals are derived to control the attenuators A4 and A5 and the 0.1 dB steps in the output monitor, A3.

For positive settings of the input control the coarse level control is set to nearest 5 dBm step above the required output and the fine level control and attenuation control are set to reduce the output to the correct level. The logic functions necessary for this are performed by IC16 and IC36 as the following example shows :-

Output level required = 8.2 dBm
(i.e. U = 8, D = 2)

Coarse level control setting = 10 dBm

Fine level control setting = 1-D = 0.8 dB

Attenuation control setting = 9-U = 1 dB

$\therefore$ Output level = 10 dBm -(0.8 + 1) dB = 8.2 dBm.

For negative settings of the input control the coarse level control is always set to 5 dBm, the attenuation control to 5 dB and the subtractive functions of IC16 and IC36 are inhibited. The fine level control and remaining attenuation controls are set to reduce the output to the correct level as the following example shows :-

Output level required = -14.5 dBm

Coarse level control setting = 5 dBm

Fine level control setting = 0.5 dB
(i.e. 0.1 and 0.4 dB)

Initial attenuation control setting = 5 dB

Additional attenuation control setting = 14 dB
(i.e. 10 and 4 dB)

Output level = 5 dBm -(0.5 + 5 + 14) dB = -14.5 dBm.

Logic description

The logic operations of the output level control board can be seen from the following tables, which correspond to each of the 4 sections shown within block A6 on Fig. 3.2. Each table shows the logic states for 5 examples of level settings.

Example 5 represents an out-of-range situation and in this case the local or remote setting is meaningless. When a '20' or '40' signal and a '+ve' signal is present a control is passed via IC23c/4, IC23a/4 and IC22d/4 to light the CHECK LEVEL lamp.

Table 3.1

Input selector logic

Local or remote setting	LOGIC OUTPUT												Example No.
	+ve	10	20	40	1	2	4	8	0.1	0.2	0.4	0.8	
+10.0	0	0	1	1	1	1	1	1	1	1	1	1	1
+17.9	0	0	1	1	0	0	0	1	0	1	1	0	2
-58.6	1	0	1	0	1	1	1	0	1	0	0	1	3
-32.4	1	0	0	1	1	0	1	1	1	1	0	1	4
+21.5	0	1	0	1	0	1	1	1	0	1	0	1	5

Table 3.2

Decoder B logic

Example No.	TP No. 13 T=0	14 20 or 40	15 T 1	16 U=0	17 U>5	18 U=5	19 D=0	TP1
1	1	0	1	0	0	1	0	0
2	1	0	1	1	0	0	1	0
3	1	1	0	1	0	0	1	1
4	1	1	0	1	0	1	1	1
5	1	1	0	1	0	1	1	0

Table 3.3.

Decoder C logic

Example No.	PIN 2	F	4	D	E	5	TP No. 20	21	32
1	1	1	1	0	1	1	1	0	1
2	1	1	0	1	1	1	1	0	0
3	1	1	1	1	1	0	1	1	0
4	1	1	1	1	1	0	1	1	0
5	0	0	1	1	1	0	0	1	1

Table 3.4

Decoder A logic

Example No.	IC16 9	6	2	15	IC36 9	6	2	15	PIN 10	L	8	9	K	1	3	2	C	H	J	7
1	1	0	1	0	1	0	1	0	1	1	0	1	1	1	1	1	1	1	1	1
2	0	1	1	1	1	0	1	1	0	1	0	1	1	1	0	1	1	1	1	1
3	1	0	0	1	1	1	1	0	1	0	1	1	0	0	0	0	0	0	0	0
4	1	1	0	1	1	0	1	1	1	1	1	1	0	1	0	1	1	0	0	1
5	0	1	0	1	0	0	1	1	0	1	1	1	1	0	0	1	1	1	1	1

3.1.5 Interface board (filter switching): A6— see Fig. 7.4

This part of the interface board contains the circuitry for controlling up to 4 band-limiting filters and up to 6 band-stop filters by either local or remote control, assuming an Automatic Filter Unit TK 2087 is fitted. If a Manual Filter Unit TK 2087/1 is fitted, the control circuitry is inoperative.

The band-limiting filters, which are selected two at a time, are controlled manually by switches CH6 to CH9 or by individual remote control signals on pins 10 to 13. Selection of local or remote control is made by IC1 and IC2 which consist of four NOR gates each preceded by two AND gates - one in the local line and one in the remote line. One of the AND gates is enabled and the other disabled by two lines whose state is determined by the setting of the REMOTE switch. The selected outputs from IC1 and IC2 each drive two transistors, which energize the 'in' and 'out' relays respectively of one of the band-limiting filters, and also light the appropriate indicator lamp D4 to D12.

The band-stop filters, which are selected one at a time, are controlled manually by switches CH1 to CH5 or remotely by a 3-line b.c.d. signal to pins 17, 18 and 19. IC3 converts the b.c.d.

input into a 6-line decimal output. Selection of local or remote control is made via IC6 which inhibits either the manual switches, via pin 17, or the b.c.d.-to-decimal decoder. As with the band-limiting filters, the selected line drives the appropriate relays and lights the indicator lamp via a pair of transistors.

Filter 6 can be either a band-limiting or a band-stop filter. For this reason, TR7 and TR8 are driven by an output from both IC2 and IC3 and each transistor energizes relays in both the band-stop and band-limiting modules.

and D10. The stable reference is taken from IC2 pin 6 via R10 to pin 5; the supply is taken through R18, R19 and R20 network to pin 4. IC2 compares these two signals and supplies a corrective signal from pin 13 to TR7 via TR3, thereby completing the feedback loop and stabilizing the supply.

In the -25.5 V supply, IC3 compares the stable reference source taken from pin 6 via R12 to pin 5 and the supply taken through R23, R22 and R21 network to pin 4. The corrective signal is then fed to the anode of Zener diode D15 to control the base of TR5.

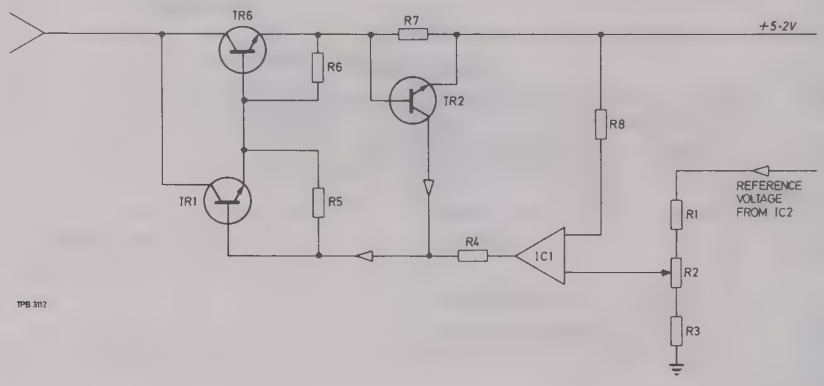


Fig. 3.3 Simplified diagram of 5·2 V power supply

3.1.6 Power supply: AB0 and AB1—see Fig. 7.6

Three stabilized supplies are derived from the two secondary windings of T1 : a +5.2 V line from Secondary 1 and +28.5 V and -25.5 V lines from Secondary 2.

In the +5.2 V supply, TR6 is a conventional series stabilizer whose output voltage is compared in IC1 with a reference voltage from IC2 in the +28.5 supply. The resultant correction voltage is applied via TR1 to the base of TR6. TR2 is a protective current sensor which conducts if the output current through R7 is sufficient to cause a voltage drop of 0.6 V. The rise in collector voltage is superimposed on the control line from IC1, turning TR6 off and reducing the output voltage.

The +28.5 V and -25.5 V supplies are similar to the +5.2 V supply except in respect of the following points. In the +28.5 V supply, TR7 is a Darlington pair transistor and the collector of TR3 is held at a constant 36 V by Zener diodes D9

Diodes D11 and D12 on IC2 inputs and D13 and D14 on IC3 inputs are to protect the IC's from excessive input currents. D16 is supplied to prevent the -25.5 V line from rising to +28.5 V in the event of an accidental shorting of these two outputs.

3.1.7 Automatic Filter Unit TK 2087—see Fig. 7.7

This unit contains the relay switching arrangements for up to four band-limiting and up to six band-stop filters.

The band-limiting filters each have two 'in' relays and one 'out' relay. The band-stop filters each have two 'out' relay contacts in series in order to give the necessarily high shunt impedance when the filter is switched in. Compensation for the residual impedance of the band-stop relay contacts is provided by an equalization network R1 to R4 and C1 to C3. This gives a level frequency response and brings the 39 Ω impedance of the output amplifier up to 75 Ω so as to match the impedance of the filters.

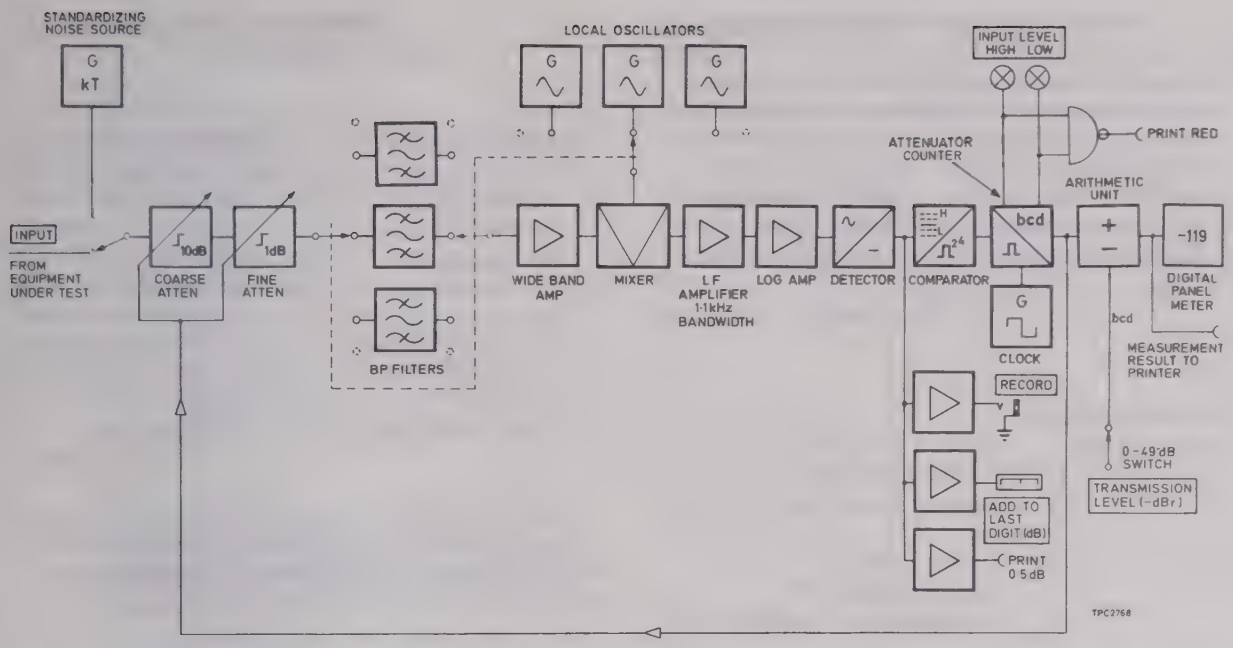


Fig. 3.4 Receiver block diagram

3.1.8 Manual Filter Unit TK 2087/1

This unit, which is an alternative to the automatic filter unit, houses up to nin band-stop and band-limiting filters. These are selected by the switches on individual filter units. The push-button switches used for the automatic filter unit are inoperative.

3.2 NOISE RECEIVER TF 2092C

Overall description

The noise signal from the equipment under test enters the receiver and is filtered to permit a single channel to pass to the mixer (see Fig.3.4). The pass band is mixed with its centre frequency from the local oscillators and the resulting l.f. signal is logarithmically amplified and rectified to produce a d.c. analogue signal that is linear with respect to dB of receiver input.

The analogue d.c. is compared to a set of d.c. reference levels in a comparator and the comparison result is fed, as a pulsed digital signal, to the attenuator counters. The counters step the input attenuators up or down via a feedback loop and, by this means, bring the signal to the comparators within limits. This self-balancing loop 'zeroes' the receiver against the input noise.

When the input noise level changes by a set minimum (19 dB in this case), the receiver zeroes to the new level and the arithmetic unit compares the new level with the original level and delivers the n.p.r. measurement result to the digital display and the printer output. Alternatively, if the receiver is first zeroed against the internal standard noise source, the arithmetic unit will deliver channel power measurement results - either weighted, unweighted or relative to zero transmission level.

An analogue output to a pen recorder is also provided.

3.2.1 Standardizing noise source: A1— see Fig. 7.9

Noise diode D1 is reversed biased and passes a preset current which is controlled by R2 and R12. The diode emits noise in the range 10 kHz to 13 MHz and this is amplified by common emitter TR1. The noise output level is set in calibration by R7. C5 maintains the frequency response of TR1 flat. With the output (board pins 1 and 5) terminated into a 75 Ω impedance, a noise reference level of -90 dBm per 3.1 kHz bandwidth (1 pW per channel) is produced. The circuit is extensively protected against r.f. pick-up by decoupling capacitors.

The noise signal from the equipment under test enters the circuit on board pin 7. This signal, or the noise from D1, may be switched onto the output by RLA and RLB. When the standardizing noise source is in use, the external noise input is terminated into 75 Ω (R9). Relay driver TR2 is turned ON (inject 1 pW selected) by a switched 5.2 V signal on board pin 3; switching being accomplished by the front panel push-buttons as follows :

Standardizing noise source applied = Inject 1 pW/channel button : IN
Zero button : OUT
Remote control button : OUT
or
Zero button : IN
NPR button : OUT
Remote control button : OUT

Inject 1 pW/channel can also be selected from the remote control connector, see Table 4.3.

RLA is screened to prevent high level noise signals entering the instrument from affecting the noise source output.

3.2.2. Input attenuators: A2 and A3—see Fig. 7.10

Attenuator board A2 consists of 75 Ω 'T' pads connected in a ladder network. The pads can be switched in and out of circuit by means of reed relays. Attenuator board A3 is identical to A2 except that the resistor values are changed to give different attenuation levels. Both boards are enclosed in screening boxes and the boxes are bolted together to form a single switched attenuator unit; the output of A2 being connected to the input of A3.

Each pad may be switched into the ladder by a t.t.l. '0' level on the appropriate board pin (see below). Each pad in the attenuator has one relay to switch the 'T' upright and another relay to switch the 'T' bar. The 'upright' relay is energized directly by the '0' input to close its contact. The 'bar' relay is de-energized by the same input, via an inverter in IC1, to open its contact. (NOTE : A2 pin 1 and A3 pin 1 both operate two 20 dB pads to give 40 dB attenuation and in this case there is a double inversion in IC1 to drive both 'upright' relays - RLB and RLC.)

Table 3.5
Attenuator switching inputs

Switching input Pin no.	Attenuation switched into line
A2 pin 1	40 dB
A2 pin 2	20 dB
A2 pin 3	10 dB
A2 pin 4	8 dB
A3 pin 1	40 dB
A3 pin 2	4 dB
A3 pin 3	2 dB
A3 pin 4	1 dB

By applying t.t.l. '0' to all combinations of switching inputs, the attenuator can be switched from 0 dB to 125 dB in steps of 1 dB.

All relay coils are a.c. coupled to earth with 0.1 μF capacitors to prevent the signal line being affected by noise spikes on the logic lines and to protect the inverter inputs from transient voltages when the relay coil current is switched off. The 160 pF capacitors in the 40 dB and 20 dB pads compensate for the frequency dependent resistance of the relay contacts which becomes significant at low values of attenuator resistance.

Inductors L1 to L6 prevent switching signals on the logic lines appearing in the attenuator output. Ferrite beads X1 and X2 damp any ringing in the attenuator conductors so as to keep the attenuation flat at all 'in-range' frequencies.

3.2.3 Filter Unit TK 2086—see Fig. 7.20

Introduction

TK 2086 is a self-contained unit which plugs into the noise receiver. The unit houses up to six CCIR recommended band-pass filters corresponding to the slot filters in the noise generator. The unit also houses the local oscillators corresponding to the filter centre frequencies. The unit provides for manual and remote selection of filter and local oscillator and for the equalization of channel gain. The unit is retained in the receiver by two captive screws which are accessible from the front face of the receiver.

Chassis and motherboard : AC1

Six 4-pole relays, RLA to RLF, (one per channel) are actuated by the 'channel select' push-button switches on the unit front panel. An electrical interlock ensures that, if more than one channel is selected, only the highest numbered channel selected is operative. The relays may also be operated remotely from the remote control socket on the rear of the receiver via the programming board and PL3. (See Table 3.6 for remote control interface signal levels.)

The four poles of RLA to RLF are used as follows :

Pole 1. Select channel gain equalization resistor R1 to R6. These resistors are adjustable by screwdriver from the unit front panel.

Pole 2. Actuate band-pass filter input/output switch relays in AC2 and AC3, thereby switching the filters into the signal line between PL4 and PL2.

Pole 2 also switches the +25 V supply to the channel indicator lamps LP1 to LP6.

Pole 3. Switch decoupled positive supply to local oscillator board via SKT1 to 6.

Pole 4. Switch local oscillator output to mixer via PL1.

The selected filters and oscillator boards must be assembled into the unit as described in Sect. 4.5 and 4.6. Input and output impedance for the filters is as follows :

PL4, input : 75 Ω
PL2, output : 750 Ω

Band-pass filter input and output switches : AC2, AC3.

Both switch units are identical except for the coaxial cable used. The units each contain six reed relays which switch filters 1 to 6 respectively into the noise signal line. The relays are activated by switching contacts on the 'channel select' relays.

Local oscillator boards

A wide selection of oscillator boards is available to suit the filter channel frequencies.

The boards 54493 series, 54496 series and TM 7793, 94, 95 series are listed in Appendix I. The 54493 series are mainly crystal type above 98 kHz. A typical circuit of a 54493 series oscillator is shown in Fig. 3.5.

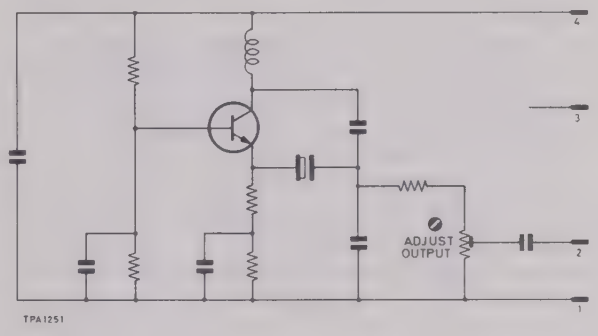


Fig. 3.5 Typical oscillator circuit

3.2.4 Oscillator junction box

This is a coaxial 'T' junction for routeing the local oscillator signal to the mixer box and to the rear panel for external monitoring purposes. There is a 680 Ω resistor in the line to the rear panel connector (oscillator output) to prevent the oscillator output from being significantly loaded.

3.2.5 Mixer: A5—see Fig. 7.12

Having passed through the input attenuators and a band-pass filter, the noise signal from the equipment under test enters the mixer board via the input coaxial connector and board terminal 1. The noise signal enters a two-stage wide band amplifier whose input impedance is 750 Ω. A feedback pair, TR1, TR2, provides voltage amplification and is designed for a low level of inherent noise. C2 gives a flat response to this stage and d.c. stabilization of the operating point is provided by R7. R5 improves the noise performance at the lower end of the frequency range by reducing the source impedance of TR2.

Table 3.6

Interface to receiver — PL3 pin functions

Pin No.	Signal description	Signal state
INPUTS		
3	Select channel 3	SELECT = Open collector ON state (0.4 V max.) NOT SELECTED = Open collector OFF state. (floating collector)
5	DC supply	+25 V
7	Select channel 5	As pin 3
9	Switched earth	0 V = 'channel select' buttons enabled floating = 'channel select' buttons disabled
10	Earth	0 V
11	Screen for pin 12	0 V
12	LF measurement from mixer LF amplifier	40 Hz to 1.1 kHz
14	Select channel 2	As pin 3
16	Select channel 4	As pin 3
18	Select channel 6	As pin 3
20	Select channel 1	As pin 3
24	Earth	0 V
OUTPUTS		
22	Screen for pin 23	0 V
23	LF measurement signal to SET ZERO potentiometer.	40 Hz to 1.1 kHz

The common emitter TR3 provides a buffer into the mixer and this stage has frequency compensation applied to the emitter by C9 and C10 to give a flat response over the noise frequency range. The high-pass filter C11, L1, C12, attenuates frequencies below 10 kHz and in particular it cuts out 50 and 100 Hz hum.

The input impedance of the mixer IC1 is set at 75 Ω by R16. R17 is a base stopper to prevent oscillation. The voltage gain of the complete circuit, from signal input to l.f. output (board terminal 11), is adjusted by the mixer preset R23.

IC1 is used as a double balanced mixer.

The noise signal from the wide band amplifier is applied across the signal input pins 1 and 4 and the local oscillator drive at the centre frequency of the noise input is applied across the carrier input pins 7 and 8. The carrier switches the signal current onto the balanced output pins 6 and 9. R18 provides a balance for the total resistance between pin 4 and earth. The local oscillator drive is attenuated by a resistive divider (R34, R19) because the oscillator output is too high for the mixer. Pins 5, 7, 8 and 10 are very sensitive to noise in the power lines and these pins are extensively decoupled. A 'single sided' output is taken from pin 9 and pin 6 is decoupled. R28 across the output terminates the mixer correctly for the l.f. amplifier section.

The l.f. amplifier consists of two identical operational amplifier stages, each with a gain of 10 to give a gain of 100 at mid-band. The cut-off frequency is 1.1 kHz and the design is for a maximally flat response. The output signal, 40 Hz to 1.1 kHz, is next routed to the receiver on the control board, A7.

3.2.6 Control circuit: A7—see Figs. 7.14 to 7.16

(1) INTRODUCTION

The circuit detects a reference noise signal and compares it to a reference level. Under the control of the master clock, the control logic switches the input attenuators until the comparators indicate that the reference noise signal equates with the reference level. The arithmetic unit within the control circuit keeps track of the attenuators. A change in noise power entering the circuit will cause the circuit to re-balance at the new level and the arithmetic unit will calculate n.p.r. or channel power according to the front panel push-buttons selected. The circuit provides measurement result outputs to the digital display.

Outputs from the circuit drive the 'high' and 'low' input level lamps and a pen recorder output; also a set of outputs to a printer provides timing pulses and measurement data. For channel power measurements, the setting of the transmission level switch (-dBr) is digitally added to the display by the arithmetic unit which forms part of the circuit.

(2) MEASUREMENT SIGNAL RECEIVER

Level control and low-pass filtering

The l.f. measurement signal (40 Hz to 1.1 kHz) from the mixer arrives on pin B and is fed to the inverting input of amplifier IC1 via relay contacts RLA/1. RLA/1 open while the input attenuators are changing so that any large transients do not affect the noise measurement - see 'Input blanking relay' below. IC1 and its associated components form a low-pass amplifier with a cut-off frequency of 5 kHz; this amplifier removes any remaining local oscillator components. R2 adjusts the amplifier gain between 21 and 23 dB.

Last $\frac{1}{2}$ dB level control and channel gain equalization

Part of the amplified l.f. measurement signal leaves the board on pin A. The signal is routed to the 'set zero' potentiometer through one of the six 'equalize channel gain' potentiometers see Fig. 7.10. These potentiometers adjust the signal level at the logarithmic amplifier output (IC4 pin 5) to compensate for the effects of different input filters etc. The signal re-enters the board on pin M and goes to one of the logarithmic amplifier inputs (IC4, pin 7) and TP1.

Log to lin conversion

The l.f. measurement signal from IC1 is also fed to the non-inverting amplifier IC2 which provides a 12.5 dB gain. The diode switch, D2 to D5, and associated resistors, R7 to R10, limit the voltage swing at IC3, pin 3, to +3 V, -2.9 V. Limiting the voltage in this way ensures an undistorted output from the logarithmic amplifier IC4. IC3 is a unity gain, non-inverting buffer which isolates the voltage limiter from the low impedance input of the logarithmic amplifier.

The split measurement signal is summed in IC4 and the output, pin 5, provides an l.f. signal whose level is linear relative to decibels of receiver input. (The reason for the split path is to change the shape of the log. amp. output to compensate for the inherent noise level of the receiver.)

Signal detection

IC5, IC6 and associated components form a full-wave rectifier. The output of IC5 takes the following form :

This is added in summing amplifier IC6 effectively to twice the original log-amp. signal.

Components from IC5 | Components from IC4 | Summation at IC6 input

The detector gives good linearity down to very low levels. The gain of IC6 is adjustable by 'select in calibration' resistor R18 to compensate for variations in the dB/mV scale factor of the logarithmic amplifier. The rectified signal is smoothed by C9.

Signal zeroing and weighting

The d.c. level at C9+ is the detected measurement signal. The input attenuators are switched, under the control of the comparators (IC12 and IC13), to bring the d.c. signal to its 'zeroed' level (about 1.7 V).

The detected signal is applied to the summing point of inverter-amplifier IC8. R24 reduces the signal level at the summing point and R62 provides adjustment to zero the amplifier output at TP4. When RLB is actuated, R21 draws current from the summing point to give -0.5 dB reduction in signal level. Similarly, when RLC is actuated, R22 supplies current to the summing point to give 0.5 dB increase in signal level. In either case, -2 dB is added to the d.v.m. reading by the arithmetic unit (described below) to give a total of -2.5 dB or -1.5 dB for psophometric or C-message weighting respectively.

Note that when the comparators (IC12 and IC13) are in limits (circuit balanced), TP4 is at a nominal 0 V potential. Also, the measurement signal at TP4 is inverted. i.e. a negative swing = increase in noise power.

Record output

The measurement signal from IC8, pin 6, enters the 'record' inverter amplifier IC10. IC10, pin 6, provides an analogue output to a pen recorder on board pin 10. R27 and R28 adjusts IC10 output so that, with the analogue meter centred on zero, there is 1 V at the 'record' output. The 'record' output has a range of 5 dB to +10 dB relative to the meter zero (0 - 3 V linear output). D11 prevents the 'record' output from being driven below -0.6 V from internal or external sources.

Analogue meter drive

The measurement signal also drives the meter amplifier, IC11. This amplifier drives the analogue panel meter via RLD/1 and the return current from the meter goes to 0 V via RLD/2. RLD operates to reverse the panel meter connections so that the analogue reading will usually be added to the d.p.m. reading regardless of reading sign - this is explained below.

Board pin 9 (and R31) may be disconnected from earth by operating the 'meter x5' button thereby decreasing the gain of IC11 to give a wider range on the analogue meter.

10 dB comparator

The measurement signal is also fed to two comparators (IC13 pins 6 and 13). Each comparator has its non-inverting input held at a 'limit' voltage by potential dividers R41 to R46. The output voltage from each comparator (pins 1 and 8) will be t.t.l. '0' if the measurement signal voltage is more positive than the limit voltage or the output will be the t.t.l. '1' if the measurement signal voltage is less positive than the limit voltage.

When the circuit has reached a balanced state, noise entering the instrument is attenuated to a level that produces approximately 0 V at the comparator inputs. If the noise signal changes by more than 6 dB up or down, the 10 dB comparator provides an out-of-limits output which causes the 10 dB step attenuator to switch up or down, thereby bringing the signal at the comparator inputs back within limits; see Fig. 3.6.

Note that the measurement signal polarity is inverted at the comparator inputs so that a more negative voltage is a higher signal level; this enables the comparator outputs to be at logical '1' to indicate 'signal level higher than limit' as shown in Fig. 3.6.

COMPARATOR INPUT STATES		COMPARATOR t.t.l. OUTPUT STATE	
REFERENCE INPUT	NOISE SIGNAL (IC13, pins 6 & 13)	LOW LIMIT (TP8)	HIGH LIMIT (TP9)
+	Out-of-limits LOW (signal > 6 dB down)	0	0
+ ref (IC13, pin 5)			
0 V	In-limits	1	0
- ref (IC13, pin 12)			
-	Out-of-limits HIGH (signal > 6 dB up)	1	1

VOLTAGE

Fig. 3.6 10 dB comparator input and output conditions

1 dB comparator

The measurement signal is also fed to two comparators (IC12) via IC9. IC9 and potential divider R38 to R40 form a non-inverting, unity gain buffer and voltage limiter into pins 6 and 13 of the comparators. When the circuit has reached balance (signal within ±1 dB) RLF/1 operates to switch the additional smoothing (C13, C14) onto the signal line so that fast noise spikes do not switch the 1 dB comparators - see 'Balanced state smoothing relay' below. The comparators exhibit hysteresis so the outputs do not change state unnecessarily due to minor excursions about the 'limit' voltages - see following circuit description.

Each comparator has its non-inverting input held at a 'limit' voltage by potential dividers R41 to R47. The output voltage from each comparator (pins 1 and 8) will be t.t.l. '0' if the measurement signal voltage is more positive than the limit voltage or the output will be t.t.l. '1' if the measurement signal voltage is less positive than the limit voltage.

When the circuit has reached a balanced state, noise entering the instrument is attenuated to a level that produces approximately 0 V at the comparator inputs. Assuming that RLD and RLE are not actuated, then the comparators will produce an 'out-of-limit' output when the noise changes by more than 0.8 dB up or down. With RLD actuated, R43 is shunted by R47 and the limits become +0.2 dB, -0.8 dB; or, with RLE actuated, R46 is shunted by R47 and the limits become +0.8 dB, -0.2 dB. Operation of RLD or RLE therefore biases the panel meter so that the analogue reading will usually be added to the d.p.m. reading regardless of reading sign - this is explained below under 'comparator limit switching and meter reversal'.

The out-of-limits output causes the 1 dB step attenuator to switch up or down (or the 10 dB attenuator; e.g. 9 dB + 1 dB or 0 dB - 1 dB) thereby bringing the signal at the comparator inputs back within limits - see Fig. 3.7.

COMPARATOR INPUT STATES		COMPARATOR t.t.l. OUTPUT STATE	
REFERENCE INPUT	NOISE SIGNAL (IC12, pins 6 & 13)	LOW LIMIT (TP6)	HIGH LIMIT (TP7)
+	Out-of-limits LOW (signal > 0.2 or 0.8 dB down)	0	0
+ ref. (IC12, pin 5)			
0 V	In-limits	1	0
- ref. (IC12, pin 12)			
-	Out-of-limits HIGH (signal > 0.2 or 0.8 dB up)	1	1

VOLTAGE

Fig. 3.7 1 dB comparator input and output conditions

(3) CONTROL LOGIC

Master clock

The comparator outputs are required to switch the 10 dB and 1 dB attenuators but in practice the comparators may be changing over from one state to the other quite a lot due to the noisy nature of the signal applied to them. Therefore, the comparator outputs are sampled at approximately 160 ms intervals under the control of the master clock. The master clock also originates the timing pulses, CP1 to 4, which control the instrument operating cycle and the external print cycle.

The master clock, IC57, is a free-running multivibrator with a 100 Hz p.r.f. square wave output. This output is divided down by four 'D'-type bistables and the divided pulses are gated together to form control pulses CP1 to 4 at the following positions :

CONTROL PULSE	ORIGIN	TEST POINT
CP1	IC55, pin 12	TP12
CP2	IC58, pin 8	TP13
CP3	IC55, pin 8	TP14
CP3	IC58, pin 6	board pin P
CP4	IC59, pin 8	TP11
CP4	IC58, pin 4	board pin R

Fig. 3.8 shows the control pulse timing.

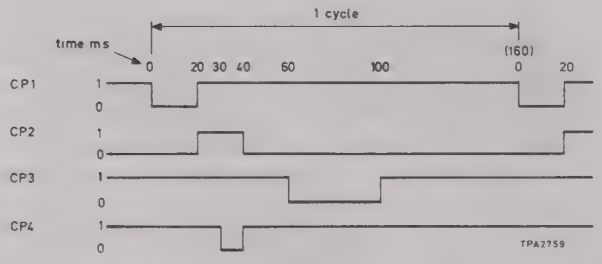


Fig. 3.8 Control pulse timing diagram

Comparator output sampling

The comparator outputs are sampled and the result is stored in four 'D' type bistables, IC16 and IC17. Two inverters, IC58 pins 10 to 13, invert the 1 dB and 10 dB low limit signals so that all four limit signals are '0' for 'in-limits'. When CP1 and 'in-limits' coincide at the NOR gate inputs (IC37), the stores are clocked by a positive-going edge which sets $\overline{Q}$ = '0'. $\overline{Q}$ = '0' is the 'in-limits' condition and when a comparator is 'out-of-limits' the store is not clocked and $\overline{Q}$ remains at '1'. Q was set to '1' when the stores were cleared by the previous CP3.

'Out-of-limits' ($\overline{Q}$ = '1') is gated with CP2 in NAND gates IC33 and IC38 and this causes a negative count pulse ($\overline{CP2}$) on the output of these gates. As the count pulse goes to '0', it drives the 'count up' or 'count down' inputs of the attenuator counters to '0'. The trailing edge of CP2 causes a positive-going edge at the 'count up' or 'count down' inputs which triggers the counters one step up or down. If the 'hold' button on the front panel is pressed, then F6 = '0' and the 'out-of-limits' signal is gated out. This facility stops the attenuators from switching automatically, which enables changes in the input signal to be monitored on the analogue meter or record output. This also permits the different channel gains to be equalized. NOR gate IC54, pins 11 to 13, gates out 1 dB 'out-of-limits' signals if a 10 dB comparator is out-of-limits so that only one counter increments during one clock cycle. C25 and C26 remove spikes which may occur due to the propagation delay in IC54.

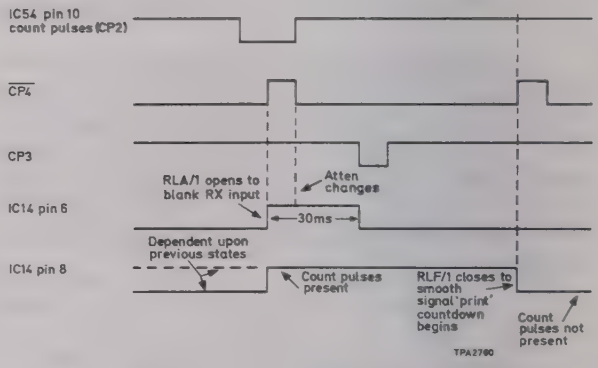


Fig. 3.9. Timing diagram for input blanking and additional smoothing

Input blanking relay (see Fig. 3.9)

A count pulse on any counter input will also appear at IC54 pin 10 and this count pulse is clocked into latch IC14 pin 2 by the leading edge of CP4. This makes $\overline{Q}$ = '1' which de-energizes RLA to open contacts RLA/1 thereby disconnecting the noise input from the receiver. The latch is reset after 30 ms by the leading edge of CP3; meanwhile the attenuator setting has changed.

Balanced state smoothing relay and print command (see Fig. 3.9)

The count pulse on IC54 pin 10 is also clocked into latch IC14 pin 12 by $\overline{CP4}$ to set Q = '1'. When the circuit is balanced, the count pulses stop and $\overline{CP4}$ sets $\overline{Q}$ = '0'. This signal is routed to the program board A4 where it starts the countdown to the 'print' command at the printer interface.

$\overline{Q}$ = '0' also energizes RLF which closes contacts RLF/1 to switch in additional smoothing to the 1 dB comparators while balance exists.

Step attenuator counters

Up/down counter IC39 is triggered by a positive-going edge on one input while the other input is held high. The b.c.d. output, 1-2-4-8, switches the input attenuator between 0 and 9 dB in 1 dB steps - a high noise input causes the counter to count up and a low noise input causes the counter to count down. Borrow and carry outputs are cascaded to the counter IC50 and positive-going edges from these outputs trigger IC50 up or down as IC39 overflows or underflows.

Up/down counter IC50 is triggered by a positive-going edge on one input while the other input is held high. The binary output switches the input attenuator between 0 and 110 dB in 10 dB steps - a high noise input causes the counter to count up and a low noise input causes the counter to count down.

Taken together, the counters switch the input attenuators between 0 and 119 dB in 1 dB steps. The counter outputs are inverted before leaving the board to provide " '0' = select " signals to the attenuators. Note that IC50, Q_D, drives board pins 14 and 25 low to select 2 x 40 dB from the one counter output.

Input level warning logic

The counter outputs are gated by NOR gates IC40 and IC51 to provide an 0 dB and 119 dB counts indication to the 'input level' warning lamps and also to prevent further triggering of the counters beyond the measuring limits. The counter output gating is as follows :

Units counter at 0 dB : IC40 pin 6 goes to '1'
Unit counter at 9 dB : IC40 pin 8 goes to '1'
Tens counter at 0 dB : IC51 pin 6 goes to '1'
Tens counter at 110 dB : IC51 pin 8 goes to '1'
Both counters at 0 dB : IC59 pin 6 goes to '0'
Counters total 119 dB : IC59 pin 3 goes to '0'

" IC59 pin 6 = '0' " holds IC35 pin 8 high to prevent any further 'count down' pulses from reaching the units counter. The signal also enables NAND gate IC35 pins 11 to 13 so that the next 'count down' pulse - if any - clock the 'input level low' latch (IC15 pin 11) thereby causing the 'low level' warning lamp on the front panel to light. Similarly, IC59 pin 3 = '0' prevents the units counter from counting up and also lights the 'high level' warning lamp. The input level warning signals are routed, via board pins 12 and 13, to the program board where they are used to produce the 'print red' signal to a printer.

(4) ARITHMETIC UNIT

Introduction

The attenuator settings from the units and tens counters are fed to two 4-bit binary full adders (IC63 and 64) and two 'initial attenuator setting' stores (IC42 and 49). If the instrument is switched to 'set zero' or 'n.p.r.' (and certain other conditions exist) then this initial attenuator setting is clocked into the stores by IC32 pin 8 = '1'. Basically, this setting is passed straight to both inputs of adders IC46 and 47 from the output of IC63, IC64 and the stores. In the adders IC46 and 47, the store input is subtracted from the other input and the result of the subtraction (i.e. zero) is clocked into the display latches, IC21 and 22, by CP4 which is present at the time. When the noise input to the receiver changes by more than 19 dB, the receiver re-balances at the new level and the changed attenuator setting is fed to IC46 and 47 via IC63 and 64 only. The subtraction is again carried out and the result (final attenuator setting - initial attenuator setting) is clocked into the display latches to give a reading of n.p.r. or channel power according to the origin of the initial reference noise (i.e. generator noise for n.p.r. or 1 pW standard noise for channel power).

Relative transmission level measurements

When measuring channel power, the setting of the 'transmission level' switch on the front panel is added directly into the result by IC63 and 64. Any setting on this switch turns the display driver TR2 ON to illuminate the channel power units with suffix '0' only. When the transmission level switch is at zero, TR3 is ON and only the power units without suffix '0' will light.

Binary/b.c.d. conversion of measurement units

IC66 and the associated gating from the output of IC63 forms a binary-to-b.c.d. converter with a carry 10 line to IC64. The conversion is necessary as the sum of the two b.c.d. inputs to IC63 can run through the b.c.d. code into binary code.

Weighting the signal for C-message and psophometric measurements

With C-message weighting selected on the front panel, board pin U goes low and RLC operates to add $\frac{1}{2}$ dB to the detected signal at the summing amplifier input, IC8. With psophometric weighting selected, RLB operates to subtract $\frac{1}{2}$ dB from the detected signal. In either case IC32 pin 6 goes high to indicate that 2 dB must be subtracted digitally from the output. These adjustments to the signal cause the display to be changed by -1.5 dB for C-message and -2.5 dB for psophometric weightings.

The 'add 2' gating takes part of the attenuator initial setting units (2-9 dB) from the store, IC42, and adds this to the 2 dB weighting (IC32 pin 6). When the 2 dB weighting pushes the initial setting above '9', IC31 pin 8 goes low to provide a 'subtract 10' input to IC48 which contains the initial setting tens and hundred. The initial setting units are fed to adder IC46 in inverted form.

Arithmetic for measurement units

IC46 subtracts the units initial setting from the final setting using 2's complement arithmetic.

i.e. Final setting + complement of initial setting + 1 dB.

The initial setting arrives at IC46 in complement (inverted) form and the 1 dB is added by a permanent +5 V on pin 13.

When the final setting + transmission level $\geqslant$ initial setting + weighting, the output of IC46 is positive (pin 14 high = +) and numerically correct in b.c.d. This output is fed to the display latches IC22.

When the final setting + transmission level $<$ initial setting + weighting, the output of IC46 is the 2's complement of the units result and the units are negative (IC46 pin 14 low = -ve). The negative sign borrows 10 from IC47 and also drives IC23 pin 13 high which inserts the borrowed 10 into adder IC27. (Note : IC47 contains the tens and hundred settings.) IC27 adds the negative intermediate result from IC46 to the 10 to give the correct positive answer.

If IC47 has not got a 10 to lend, the sign for the whole measurement result goes negative (IC29 pin 6 goes high) which removes the borrowed 10 from IC27. The overall negative sign also sets 'D' latch IC19 pin 10 high. This re-inverts the units result by applying a '1' to EXCLUSIVE-OR gates IC45. IC19 also adds 1 to the units result in IC27 and this procedure decodes the 2's complement output of IC46 to give the correct negative units result.

Circuit for tens and hundred attenuator setting

The 'tens' and 'hundred' attenuator setting is in binary code but is handled in the same manner as the units : the inverted contents of the initial setting store IC49 are taken to the adder IC48 where the 'subtract 10' signal from the units initial reading may be deducted (t.t.l. '0' = subtract). Also, when the 1 mW channel power button is selected, 90 dB is subtracted from IC48; i.e. pin 1 and 10 = t.t.l. '0'. (This is because the 1 pW internal standard is still used for 1 mW related measurements and this would cause the display to read 90 dB too high.)

The output of adder IC48 gives the attenuator tens and hundred setting minus 10 (if borrowed) minus 90 (if selected by 1 mW button). The output is in complementary form in the same way as the units.

IC47 subtracts the initial setting from the final setting using 2's complement arithmetic.

i.e. Final setting + complement of initial setting + 10 dB.

The 10 dB is added on pin 13 when the units are positive.

When the final setting + transmission level $\geqslant$ initial setting +90 (if 1 mW button selected), the output of IC47 is positive (pin 14 high = +) and numerically correct in binary code.

When the final setting + transmission level < initial setting +90 (if 1 mW button selected), the output of IC47, is the 2's complement of the result and is negative (pin 14 low = -ve). The negative sign drives IC29 pin 6 high to provide the overall minus sign. If the units are negative, the minus sign decodes the units as previously described. If the units are positive, the minus sign subtracts 10 from the units using 2's complement arithmetic (IC23 pin 13 is driven high). As the latch, IC19 pin 10, is also held high, adder IC27 can count through b.c.d. '-9' to binary '-10'. This state is detected by NAND gate IC26 pins 12 and 13 and a 'carry-10' is passed to IC28 pin 13. At the same time, the b.c.d. -'10' is blocked by NAND gates IC26 pins 1-3 and 8-10 and the inverters TR4 and 5 drive the '8' and '2' lines low to give a zero units output.

IC44 and adder IC28 decode the 'tens' and 'hundred' 2's complement in the same way as the units. (The effect of inverting the reading in IC44 and 45 is to subtract the final setting from the initial setting as the initial setting is the larger number in this case.)

Adder for the binary '160' bit

The ESCLUSIVE-OR gates IC29 pins 4-6 and 8-10 form an adder for the carry bits from the tens and hundred adders. These binary '160' bits control the internal arithmetic and determine the reading sign but do not affect the numerical reading. When the binary sum of the three carries is odd (IC29 pin 6 = '1') the reading sign is negative. Carries from this '160's' adder are lost.

Binary/b.c.d. converter for tens and hundred result

The reading is gated to provide a '1' on IC19 pin 8 whenever the reading is 100 dB or more. 100 is subtracted from IC28 by adding the complement of 10 (0110). This decodes the reading into a b.c.d. 'tens' decade and a '100' bit and this signal is clocked into the display latches IC19 and 21.

Auto zero circuit

IC24 pin 8 goes high whenever the measurement is less than 20 dB : if the circuit is balanced and n.p.r. is selected, this '<20 dB' signal causes IC18 pin 12 to pulse low during CP4. The low pulse drives IC32 pin 8 high which clocks the change of attenuator setting (if any) into the initial setting' stores IC42 and 49. This procedure causes the display to zero automatically for small changes (less than 20 dB) of reference noise entering the receiver. When the band-stop filter is switched into the generator, the change in noise input will be greater than 20 dB and the circuit will not zero and the display will indicate n.p.r. It follows that n.p.r. measurements of less than 20 dB cannot be made. If the set zero button is selected this will also actuate the auto zero circuit by applying a '0' to IC32 pin 10; in this case, the circuit will continue to zero regardless of the magnitude of the changes to the noise input.

Comparator limit switching and analogue meter reversal

This circuit makes calculation of the measurement result, using both digital and analogue displays, as easy as possible. This is achieved by reducing the high tolerance or the low tolerance of the comparators so that the analogue reading is most likely to have the same sign as the digital reading. Also, when the reading is negative, the analogue meter is reversed so that it registers its negative excursions as a positive reading. Therefore, when the reading is positive or negative, the analogue meter will always read positive (or very slightly negative) and this positive reading will always be added directly to the digital reading regardless of sign. This leaves the operator with the simplest and least confusing task.

If the digital reading is '0' then the positive and negative tolerances are equal and the analogue meter may swing equally about 0 dB to give a positive or negative result.

The actuation of the limits switching relays RLD and RLE is controlled by conventional gating to give the following conditions :

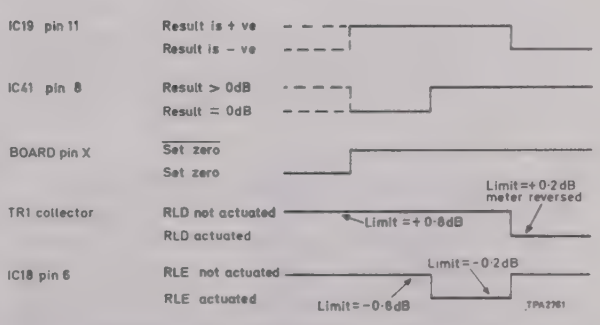


Fig. 3.10 Condition to actuate limit switching relays

Relay contacts RLD/1 and RLE/3 shunt R47 across R43 or R46 to reduce the comparator tolerances from 0.8 dB to 0.2 dB.

Results output

The contents of the display latches leave the board and are routed to the display board A6. The outputs also go to the program board A4 which routes them to the printer interface. A '0' on board pin W suppresses the leading 'zero' display as necessary.

3.2.7 Display board: A6—see Fig. 7.13

Digital display

IC1-3 forms a $2\frac{1}{2}$ digit, 7-segment LED display with minus sign. IC4 and 5 are b.c.d. to 7-segment decoder/drivers and these are driven by the tens and units measurement results from the control board; t.t.l. '1' = number present. The '100' display and the minus sign are driven directly as no decoding is required; t.t.l. '0' = illuminate.

The 'zero suppression' signal blanks the leading zero when the measurement is less than 10. When the 'set zero' button is pressed, the 5.2 V supply to the LED's is switched off and the display is blanked.

3.2.8 Program board: A4—see Fig. 7.11

General

The program board forms an interface between the receiver, an 8-column printer and the noise generator. The interface also allows the main operating functions of the receiver to be controlled from the TK 2085 or your own remote control device - see Sect. 2.3.

'Print' command : repetitive

When the receiver balances, board pin 13 goes to '0' which enables counter IC3. The counter divides $\overline{CP4}$ by 32 so that the counter output, pin 11, goes to '1' at the 16th pulse and to '0' at the 32nd pulse. The positive-going edge at the counter output clocks 'D' bistable IC2 pin 11 and, as there is a permanent '1' on the 'D' input, this sets Q to '1', and a signal via SK17 pin 6 signals receiver balance to the remote control unit if IC14 has enabled IC1 pin 3. After 20 ms, $\overline{CP3}$ arrives on board pin 16, driving IC4 pin 5 to '1'. This clears the 'D' bistable thereby generating a positive pulse at the $\overline{Q}$ output. The pulses are repeated every 5.1 s while balance exists.

The positive or the negative pulse may be used as the print command by patching link D. The negative pulse may also be used as a latching pulse to clock the print data output latches IC8, 11, 12 and 13. This facility is available by patching link J - see Fig. 4.6 patching the printer outputs table.

'Print' command : single shot

When the print trigger arrives from the remote control socket SK17, board pin 5 goes to '0' and the 'D' bistable (IC2 pin 4) is preset so that $\overline{Q}$ goes to '0'. When the receiver is balanced, IC5 pin 6 will pulse to '0' for 40 ms and, as a consequence, IC5 pin 1 will pulse to '0' for 40 ms.

Units display (A6)

Lamp No.	Units illuminated	Trans's level (-dBr)	Front panel switching required				
			NPR	1 mW	1 pW	C-Mess	psoph
LP1	dB		IN				
LP2	dBm	00	OUT	IN			
LP3	dBm0	>00	OUT	IN			
LP4	dBrnC	00	OUT	OUT		IN	
LP5	dBrn	00	OUT	OUT	IN	OUT	
LP6	dBrn0	>00	OUT	OUT	IN	OUT	
LP7	psoph		OUT			OUT	IN
LP8	dBrnC0	>00	OUT	OUT		IN	

The positive-going trailing edge of this pulse clocks the permanent '0' (IC2 pin 2 = '0') into 'D' bistable IC2 to set $\overline{Q}$ to '1' thereby gating out any further 40 ms pulses into IC5.

The 40 ms negative pulse on IC5 pin 1 or the 40 ms positive pulse on IC5 pins 2-4 may be used as the print command by patching link D. This link also allows a choice between the single shot or repetitive mode of printing. Providing that the receiver is balanced, the print command appears not more than 2.56 s. after the negative-going edge of the print trigger pulse.

The print command, to the printer, solicits a reply via board pin 31, 'printer busy'. Link J may be patched to either inhibit data exchange when the printer is busy, or to take from the $\overline{Q}$ output (of IC2) an internal clock pulse which will latch the outputs of IC8, 11, 12 and 13.

Print data latching pulse

NOR gate IC5 pins 8-10 routes the printer busy pulse to the clock inputs of the data latches via inverter IC4 pins 1 to 3. Data is transferred onto the latch outputs at the start of the print pulse and is printed immediately. Data at the outputs remains stable whilst the printer is reading and printing. As soon as the 'printer busy' signal is removed new data via IC8, 11, 12 and 13 is presented to the outputs of these i.c's.

'Print red' command

When the noise signal to the receiver is above or below the measuring range of the instrument, board pin 1 or 2 goes to '0'. This produces a '1' at IC4 pin 8. C4 charges up and emitter follower TR8 passes a '1' to the 'print red' latch. Unwanted positive pulses now arrive at board pins 1 or 2 (whichever is low) which drives IC4 pin 8 to '0' but these unwanted signals do not reach the latch because of the slow time constant of C4, R30 and isolating diode D2.

The latch Q and $\overline{Q}$ outputs may also be patched by link C to provide '1' or '0' for 'print red' to the printer.

'Print 0.5 dB' command

The signal driving the ±2.5 dB front panel meter also arrives across board pins J and 7 to drive differential amplifier IC10. IC10 inverts the input signal and applies it to the inverting input of op-amp IC9.

IC9 is connected as a regenerative comparator in open loop configuration. The 0 V reference voltage is applied to the non-inverting input via R25 and positive feedback is applied to the same point by R26. As well as causing the regenerative action of the comparator, the positive feedback causes the comparator to exhibit hysteresis so that the output does not change constantly due to minor variations of input caused by noise. The negative swing at the comparator output is held to about -0.6 V by D1.

When the meter reads +0.6 dB or more, the comparator input signal is less positive than the reference voltage and the comparator output is fully positive ('1'). When this is loaded into the latch IC8, the printer will print '.5' dB in the result. If the meter reads +0.4 dB or less, the comparator input signal is more positive than the reference voltage and the comparator output is fully negative ('0'). The printer now prints '.0' dB in the result. The 0.2 dB 'window' (0.6 dB to 0.4 dB) is due to the hysteresis of the comparator. R23/R24 provide off-set to centre the 0.2 dB 'window' about +0.5 dB meter reading.

IC14 also takes its input from IC10 and is connected in a configuration identical to that of IC9. IC14 controls the 'balance pulse' output, via IC1 pins 1 to 3 and IC4 pins 11 to 13, to signal that the receiver has 'zeroed'.

Channel selection

With the receiver switched to remote control, b.c.d. '1' to '6' applied at the remote control socket will drive b.c.d./decimal decoder IC6. This decoder has mutually exclusive inverted outputs so that an '0' appears on one output only according to the b.c.d. input. The decoder has 30 V max, open collector outputs and these leave the board on pins L to S and switch the channel selection relays in the filter tray.

The selected channel signal cuts off one of the emitter followers TR1 to 6 to apply t.t.l. '0's to NAND gate decimal/b.c.d. encoder IC7. IC7 applies the selected channel number, in b.c.d., to the print data latches in IC8 and to the remote control socket (via board pins 26 to 28) for systems use if desired.

With the receiver switched to manual (i.e. remote control button OUT) the +5 V (s) supply at board pin T is off thereby switching TR7 off. This renders decoder IC6 inoperative by switching it to channel 8 which does not exist. Manual channel selection from the filter unit is unhindered and these selections appear on board pins L to S to load the print data latches.

'Set zero' and 'Inject 1 pW/channel'

With the receiver switched to remote control a '1' from the remote control socket arriving on board pin 1 will drive board pin 14 to '0' thereby initiating the set zero sequence. The '0' for 'set zero' is also routed back to the remote control socket via board pin 3 for use as a system signal if required. Simultaneously NOR gate IC1 pin 4 is driven to '0' and board pin 15 to '1' which causes the standard noise source to inject 1 pW/channel into the receiver input. Alternatively, a 1 from the remote control socket arriving on board pin 2 will inject 1 pW/channel without setting zero.

With the receiver switched to manual, the +5 V(s) is switched off and IC1 is inoperative so that the front panel push buttons have command.

3.2.9 Power supply: AB0, AB1 and AB2— see Figs. 7.17 to 7.19

+60 V regulator

The reservoir capacitor output is regulated to a nominal 35 V by D4, D5 and D6 and this supply is connected in series with the +25 V line. R34 (AB1) provides a discharge path to earth for C5 (AB2) when the supply is switched off. The supply is short circuit proof for a limited period.

+25 V regulator

This circuit is based upon voltage regulator IC1 driving series regulator TR4/TR1 (on heatsink on rear panel). D1, D2 and R2 protect IC1 against mains high condition. VT4 is used instead of the internal series pass transistor in IC1. Output voltage sensing is taken from R35 and adjustments to this variable resistor sets the +25 V and +60 V levels. R6 determines the output short circuit current and normal current sensing is provided by IC1 pin 1. The supply is constant current limited.

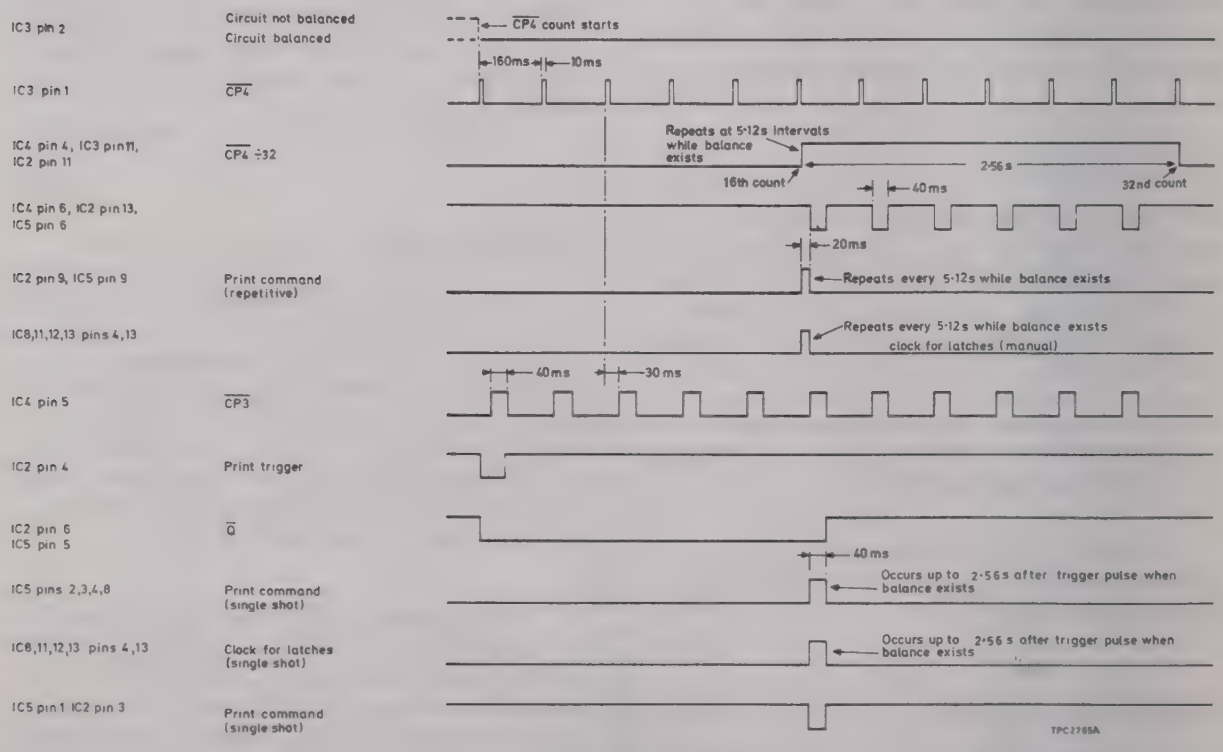


Fig. 3.11 Print command timing diagram

+5.2 V (1) regulator

IC2 and TR6 (internal heatsink) form a series regulator. Output voltage is set by R36, current sensing and limitings provided by IC2 pin 1. (Note : R36 also adjusts +5.2 V (2). Voltage sensing is via R18. The supply is current fold-back limited.)

+5.2 V (2) regulator

IC4, TR9 (internal heatsink) and TR2 (heat-sink on rear panel) form a series regulator. Output voltage is set by R36 and voltage sensing is by IC4 pin 2. Current sensing and limiting is by IC4 pin 1. Should the fold-back current limiting circuit be damaged, the receiver circuit is protected by FS1 on board AB2.

SCR1 gives 'crowbar' protection should the output voltage rise above 6.5 V. TR11 is nominally biased off : because the voltage across D8 is essentially constant, a rise in output voltage switches TR11 on. This fires the thyristor and short circuits the line.

-5 V regulator

Inverting amplifier IC3 senses +5.2 V (1) to provide the -5 V line. The series regulator TR8 (internal heatsink) and the common base current sensor TR7 are in the feedback path. Using +5.2 V (1) as the reference for -5 V has the advantage that both lines 'track' together.

3.3 FILTERS

All filters have 75 Ω characteristic impedance except for band-pass filters which have 75 Ω input impedance, 750 Ω output impedance.

There are four main groups of filters used in the test set for in-band testing.

a) High-pass TK 2096 series
b) Low-pass TK 2095 series
c) Band-stop 54491 series

} These are used in the generator and are individually switched.

d) Band-pass 54492 series

} These are used in the receiver and are not individually switched.

All the above are 'B' version filters and meet requirements of CCIR Recommendation 369-2 (1974).

Out-of-band filter sets TK 2084 series, conform to CCIR Recommendation 398-3 (1974). Like the 'B' version filters they can be used in OA 2090C and earlier test sets, viz OA 2090, OA 2090A and OA 2090B.

The following filters, designed for other versions of the test set, may be used in the OA 2090C and meet the less stringent requirements of CCIR Recommendation 399 (1963) :-

High-pass TM 7728 series,
Low-pass TM 7720 series,
Band-stop TM 7729 series,
Band-pass TM 7730 series.

In all the filters, the circuitry which consists of combinations of inductors, capacitors, and in some cases crystals, is contained on printed boards. The switched filters contain a bulkhead behind the front panel to which is attached the rocker mechanism actuating two micro-switches.

In the 'Filter-in' position the filter is switched between input and output sockets. In the 'Filter-out' position the circuit is replaced by a shorting link with a shunt 20 pF capacitor to overcome the mismatch due to the inductance of the link.

High- and low-pass filters

The high-pass and low-pass filters are generally of the coil-capacitor type. The high-pass filters are based on m-derived Darlington types and consist of capacitance-coupled series tuned L-C shunt circuits. A typical high-pass filter circuit is shown in Fig. 3.12.

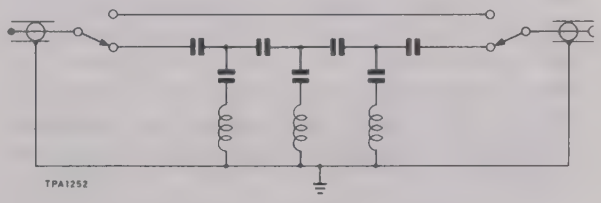


Fig. 3.12 Typical high-pass filter circuit

The low-pass filters are of the Tchebyshev type and consist of parallel tuned circuits in the series arms with capacitance shunt circuits. Equalization at the output is used to ensure minimum tipple in the pass band. A typical low-pass filter is shown in Fig. 3.13.

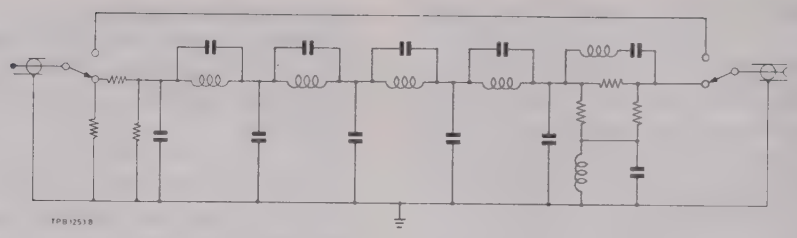


Fig. 3.13 Typical low-pass filter circuit

Band-stop

The characteristics of the band-stop filters are given in the Data Summary.

54491 series (part of TK 2094 series) see Fig. 1.3
TM 7729 series see Fig. 1.5
54494 series (part of TK2084 series) end of Sect.1.2

The filters all have 75 Ω input and output impedances. 54491 series filters employ amplitude equalizers, where necessary to give maximum flatness of the pass band. The consequent insertion loss, which depends on the type of filter, is typically 1 dB to 2 dB. Of the 54494 series filters, those above 4715 kHz employ amplitude equalizers with typical insertion losses of 0.5 dB.

A diversity of circuit configurations is used for the band-stop filters. Most are L-C types but the higher frequency (3886 kHz and above) filters of the 54491 series are crystal types. It may be noticed that some filters are hermetically sealed. This is necessary on certain designs to maintain their high Q's under conditions of high humidity.

If a filter is suspected of being faulty its characteristic can be checked using a 75 Ω selective measuring set and, if the unit is not sealed by physical inspection. Specialized test gear is required to align the filters and it is strongly advised that no adjustment be attempted. The faulty filter should be returned to our Service Division. No circuit information is given in this manual.

It should be noted that, being crystal filters, the higher frequency filters of the 54491 series exhibit spurious responses at frequencies just above the stop band and at approximately three times the stop band frequency. These spurious responses take the form of a scattering of very narrow rejection bands, each a few kHz wide and with amplitudes less than 10 dB. Their effect on an n.p.r. measurement is negligible since the power extracted by the spurious stop bands is less than 0.05 dB.

Band-pass

Band-pass filters 54492 series, 54495 series and TM 7730 series (listed in Appendix I) each have a pass band which is narrower than the slot of its corresponding band-stop filter. The characteristics of the band-pass filters are derived from the specifications of the band-stop filters and the requirements of the receiver.

In general the characteristic of a band-pass filter is such that, when combined with the appropriate band-stop filter, the all band rejection exceeds 50 dB. Input impedance is 75 Ω but output impedance is 750 Ω. Power insertion loss at the centre frequency depends on the filter type and is up to 6 dB for the 'B' version filters*. For 'A' filters power insertion loss is up to 16 dB. Attenuation relative to the pass band is at least 50 dB.

There is no common circuit configuration for band-pass filters and no circuit information is included in this manual. Certain filters of the 54492 series employ crystals in order to achieve the necessary narrow characteristics. To protect the coils under high humidity conditions, hermetic sealing is again necessary on some filter boxes.

Chapter 4

Maintenance

4.1 GENERAL

This chapter is for use in fitting filters and local oscillators, for carrying out a functional test of the white noise test set and for checking its performance. To realign the test set or to fault-find, refer to Chapter 5. In case of difficulty please contact our Service Division or your nearest Agent. Always mention the type numbers and serial numbers of your instruments.

NOTE. Performance limits quoted are for guidance only and should not be taken as guaranteed specifications unless they are also quoted in Data Summary, Sect. 1.2. When making tests to verify that the instrument meets the stated performance limits, allowance must always be made for the uncertainty of the test equipment used.

Test methods described may be simplified and of restricted range compared with those which would be needed to demonstrate full compliance with the specification. They should be regarded only as providing a check procedure, for use during routine maintenance, to determine whether or not repair is needed.

CAUTION

Semiconductor devices are used throughout the test set and, although they have inherent long term reliability and mechanical ruggedness, they are easily damaged by overloading, reversed polarity and heat or radiation. Avoid prolonged soldering, strong r.f. fields or short circuits. Do not use insulation testers. Always allow a few seconds for the h.t. electrolytic capacitors to discharge after switch off before attempting any operation on the internal components.

4.2 FUSES

The noise generator has two supply fuses rated at 500 mA for 230 V or 1 A for 115 V. These are located on the rear panel. On the receiver there are three fuses. Two fuses 500 mA for 230 V or 1 A for 115 V, are located on the rear panel, and a 5 A fuse for the plus 5.2 V (1) line is located on the AB1 board mounted inside the rear panel. Switch off the supply and unplug the supply lead before fitting a new fuse.

4.3 REMOVING THE CASE

The top and bottom covers are each secured by two M4 screws in each side.

4.4 FITTING GENERATOR FILTERS

A total of nine filters, comprising low-pass, high-pass and band-stop, may be fitted into the noise generator. These are contained in a plug-in Filter Unit type TK 2087 (programmable) or TK 2087/1 (manual).

Remove either unit from the generator by unscrewing the captive screw on each side of the front panel. Each filter is held in place by two spring-loaded captive screws passing through the body of the filter into the chassis. Note that the filter unit will not fit into the generator if the filter fixing screws are not screwed fully down.

Unused filter positions may be covered using a blank panel unit type 54134-011A which is held by a single screw into the front filter fixing hole. The method of connection of filters depends on the filter unit fitted.

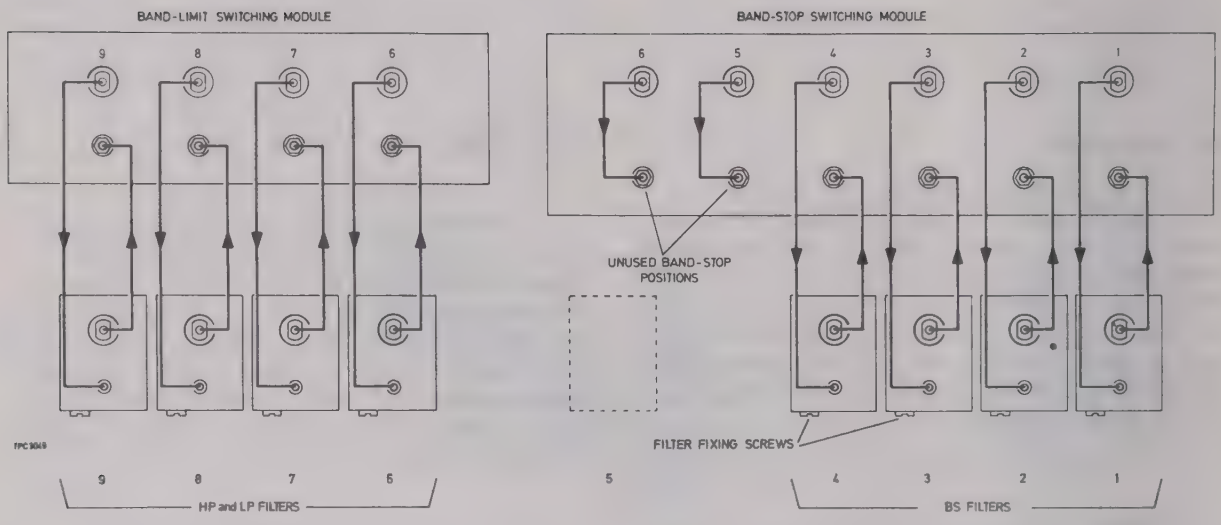


Fig. 4.1 Filter connections for Programmable Filter Unit TK 2087

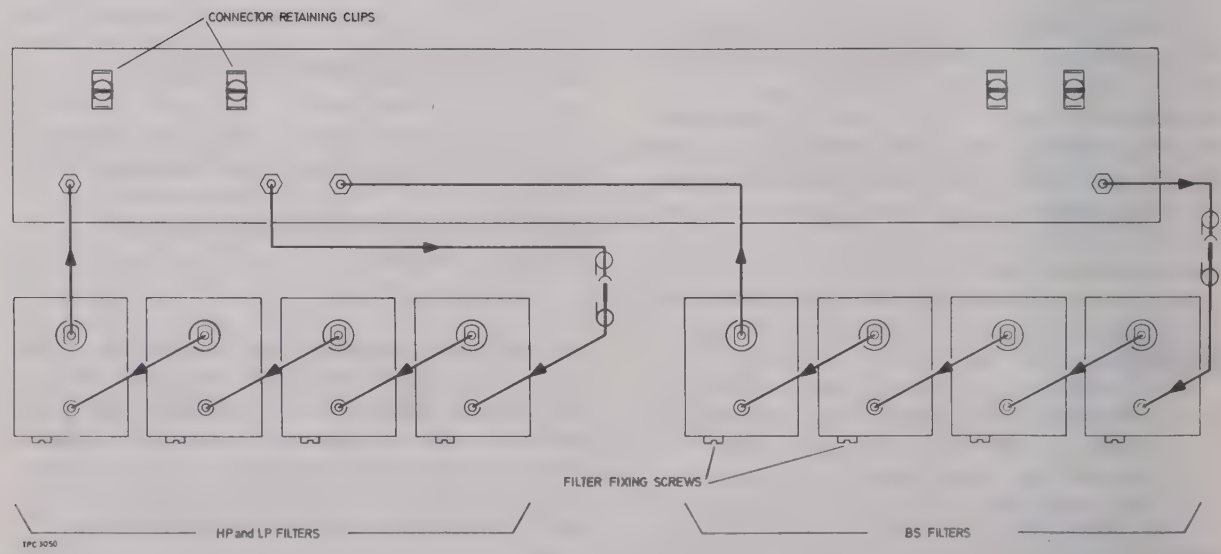


Fig. 4.2 Filter connections for Manual Filter Unit TK 2087/1

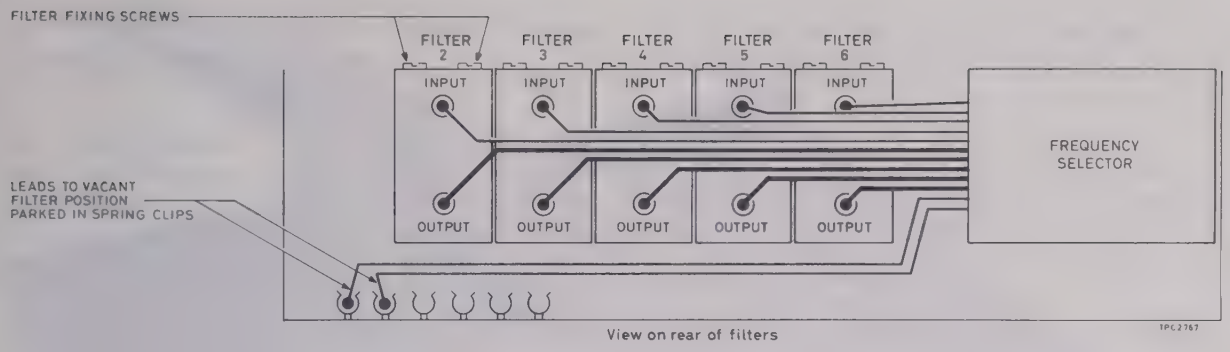


Fig. 4.3 Receiver filter connections in TK 2086

Programmable filter unit

Fig. 4.1 shows the connections for filters fitted in TK 2087.

Before fitting a filter, move the switch on its front panel to the IN position. A locking bar is fitted across the front of the unit, but this should not be relied on to operate the switch. Band-stop filters may only be fitted in positions 1 to 6 and are connected to the correspondingly numbered lead and socket on the band-stop switching module. High-pass and low-pass filters may only be fitted in positions 6 to 9 and are connected to the correspondingly numbered lead and socket on the band-limit switching module. Note that there are two leads and sockets numbered 6, the actual one used depending on the type of filter occupying position 6. Plugs for unused filter positions should be connected to the corresponding sockets as shown in Fig. 4.1.

Manual filter unit

Connections for the Manual Filter Unit, type TK 2087/1, are shown in Fig. 4.2.

There is no restriction on the mixture of filters in this unit provided that high- and low-pass filters are connected in cascade between the plug and socket on the left of Fig. 4.2 and that band-stop filters are connected in cascade between the plug and socket on the right. Use the clips provided to retain the two in-line connectors.

4.5 FITTING RECEIVER FILTERS

Fit receiver filters in the same numbered positions as the corresponding band-stop filters in the generator.

Filter Unit TK 2086 can accommodate up to six band-pass filters which are connected to adjacent pairs of plugs from the frequency selector unit as shown in Fig. 4.3.

Remove the filter unit from the receiver by unscrewing the two captive screws on the front panel. Turn the filter unit upside down to expose the filters (Fig. 4.4). The position for the new filter will be occupied by either an old filter or a blank panel at the front, which must be removed. Filters are attached by two long spring-loaded captive screws passing through the bodies of the filters into the chassis; blank panels and cable clips are held by short screws into the same holes in the chassis as are used for mounting the filters.

Screw the new filter into place. Each filter position has its own pair of leads which carry sleeves with numbers corresponding to the six positions. On the back of each filter are two BNC sockets, labelled input and output. The leads come from the frequency selector switch box as shown in Fig. 4.3. The thIN leads go to the INputs and the thick leads go to the outputs. A filter connected the wrong way round will not function. Note that each band-pass filter has an associated local oscillator board which must also be fitted in the appropriate position - see Fig. 4.4.

Never leave cables loose inside the case.

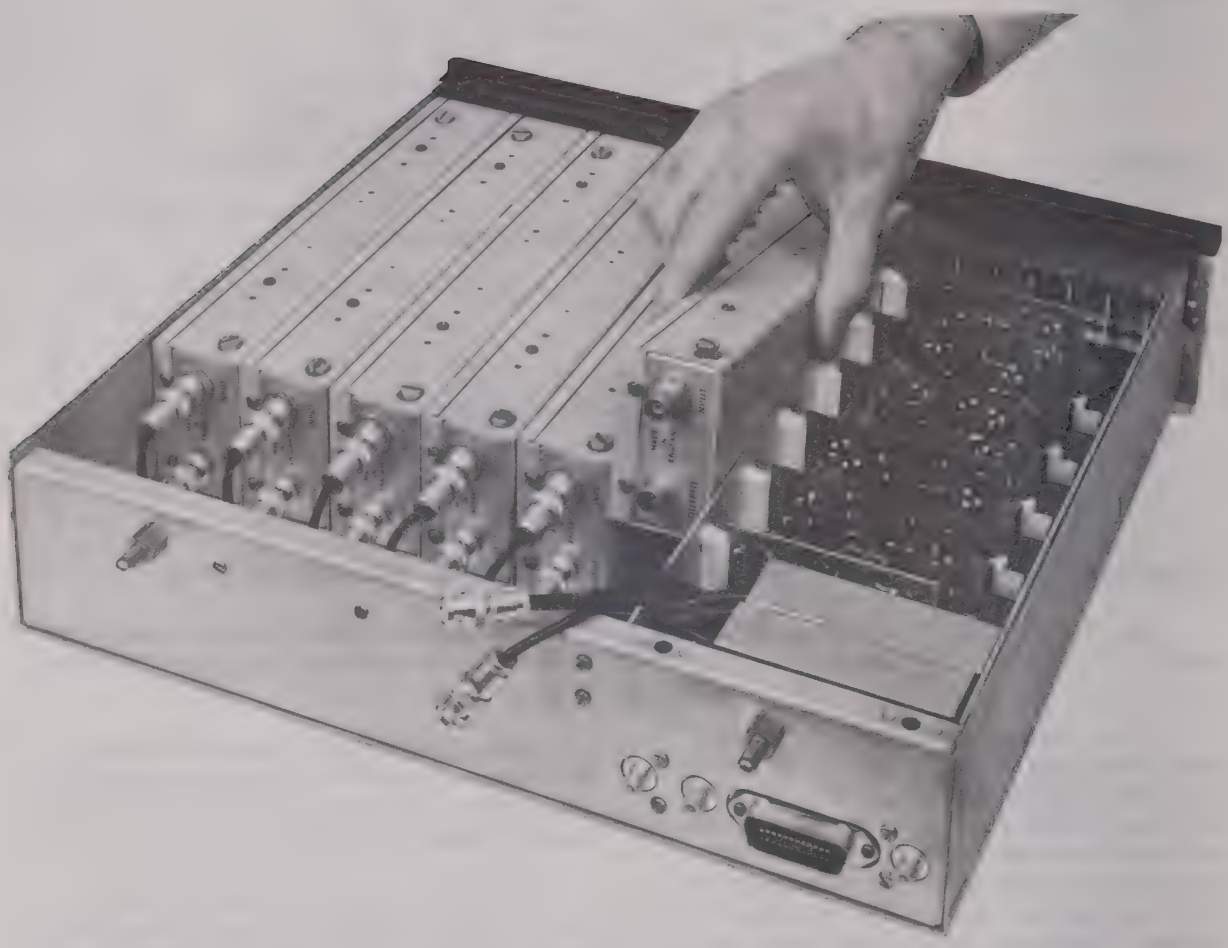


Fig. 4.4 Changing receiver filters

4.6 FITTING RECEIVER LOCAL OSCILLATOR BOARDS

Remove the filter unit as in Sect. 4.5 above. Release the frequency selector switch box lid by turning the two quick release fasteners on the back edge of the filter tray through 90° - see Fig. 4.4.

Inside the box the oscillator boards fit into sockets and are steadied by slotted plastic guides. The sockets are numbered from 1 to 6 to correspond to the frequency selector switches and band-pass filters.

Press the board firmly into its socket and replace the selector switch box lid.

4.7 FITTING THE PROGRAM BOARD

(1) Remove the filter tray from the receiver. Remove the top and bottom covers from the receiver by unscrewing four M4 screws from each side of the instrument.

(2) Release the four M4 screws securing the power supply and mains transformer to the underside of the main chassis. Hinge the rear panel down by removing the top three M4 screws on each side of the panel and slackening the bottom screw. Remove the coaxial connectors to SK9 and SK10.

(3) Hinge up the control board chassis as shown in Fig. 4.5 by removing one M4 fixing screw from each side of the instrument. (The chassis pivots on the fixing screws near the front of the instrument.)

(4) Plug the program board, component side up, into its edge connector (SK14).

(5) Using the four M3 screws and washers supplied, fix the board to the existing pillars in the main chassis.

(6) Remove the cover plates from both socket apertures on the rear panel. Retain the fixings.

(7) Insert the connector with the smaller number of wires through the hole marked GENERATOR TF 2091C and the other connector through the hole marked REMOTE CONTROL AND PRINTER OUTPUT.

Screw both connectors to the rear panel using the fixings from (6).

(8) Hinge the rear panel back to its original position and replace the fixing screws. Take care not to pinch the program board cableform.

(9) Check, and if necessary change, the position of links on the program board (see Sect. 4.8).

(10) Replace the coaxial connectors to the mixer and attenuator boxes. Replace the control board and fix. Replace top and bottom covers and fix.

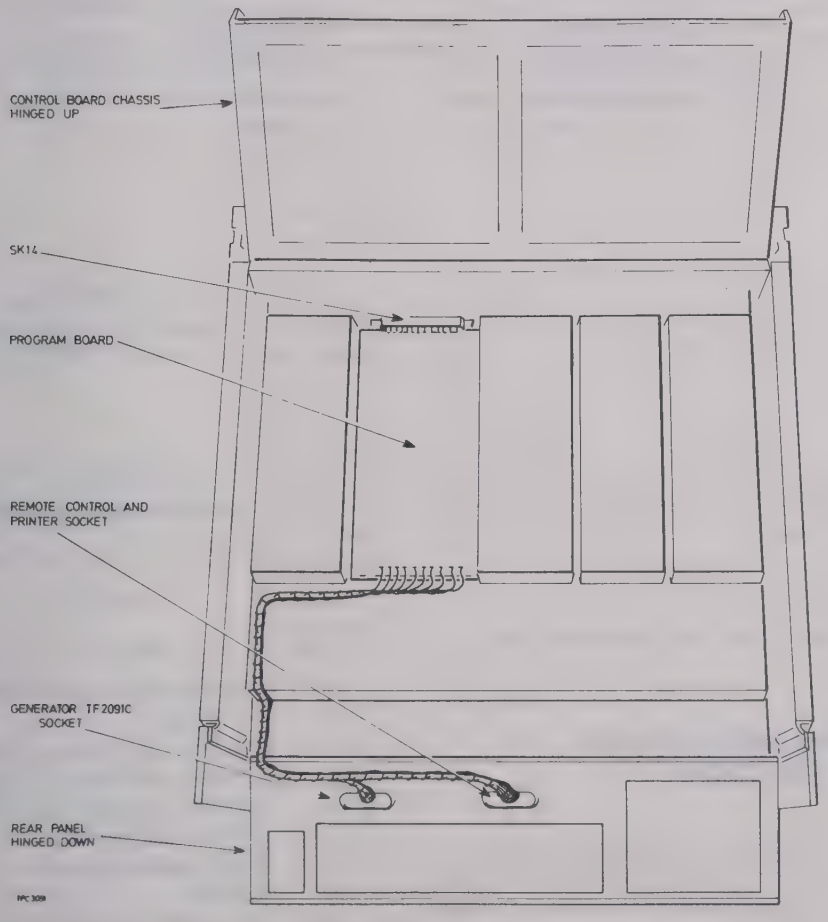


Fig. 4.5 Program board assembly viewed from the top of the receiver

4.8 PATCHING THE PROGRAM BOARD

Program board 54490-032H; patching the printer outputs

SK17 Pin No.	Output signal name	TTL signal required to suit printer	Link
4	Print command (single shot)	⎍	D - G D - H
	Print command (repetitive)	⎍	D - F D - E
24	Print red	0 1	B - C A - C
34	Printer busy	1 0 not used	L - J M - J K - J
NOTE : For GMT Printer (after removing existing links)		Link L - J Link B - C Link D - H for single shot or D - E for repetitive	

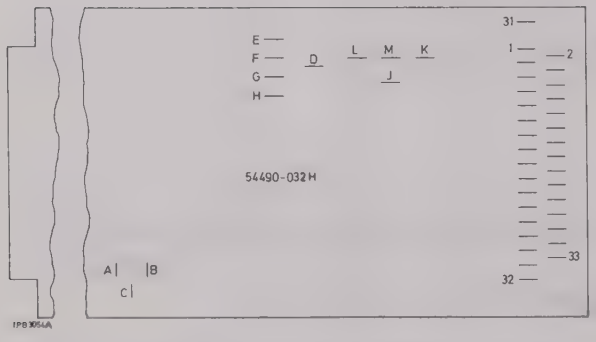


Fig. 4.6 Program board 54490-032H; patching pin layout

4.9 GENERATOR AND RECEIVER INTERCONNECTION

When a connecting lead longer than the 1.2 m of accessory lead 43129-144X is required, the lead should be wired in accordance with Table 4.1 using the two Amphenol 36-way plugs supplied in accessory kit 46883-271K. Where the lead may also be required to connect the generator to Control Unit TK 2085, it should be wired as described in Sect. 4.1.1 of the TK 2085 manual. Suitable cables are multicore screened types with conductor size of either 7/0.2 mm or 7/0.1 mm.

Table 4.1

Generator connection to receiver

TF 2091C (SK18) Pin No.	Function	TF 2092C (SK17) Pin No.
14	Remove band-stop filters	14
16	Noise off	16
17	Select b-s filters, b.c.d.1	17
18	Select b-s filters, b.c.d.2	18
19	Select b-s filters, b.c.d.4	19
20	Plug sense send	20
21	Plug sense return	21
29	Earth	29
31*	Generator level warning	31

* Provides generator level warning to printer via receiver if required.

4.10 RECEIVER CONNECTION TO PRINTER

4.10.1 Receiver connections

The code character relationship shown in Table 4.2 applies to many printers including the first nine types listed in Sect. 2.4.4. Table 4.3 lists the pin numbering sequence of the receiver REMOTE CONTROL & PRINTER socket. Table 4.4 is derived from these two tables and relates the b.c.d. 1, 2, 4 and 8 pins of each printer column to the receiver REMOTE CONTROL & PRINTER socket. The pins in Table 4.3 marked † will not be wired since they are for remote control only.

Print command and receiver out of range signals to the printer may be selected by program board patching to be at either positive or complementary logic levels. Similarly the receiver accepts a 'printer busy' signal in either sense. Link patching on the program board is described in Sect. 4.8.

4.10.2 Print command mode

The print command function can be set by means of program board links (see Sect. 4.8) to work in either of two modes.

(i) Single shot : a single print command pulse occurs following application of a print trigger pulse to the receiver.

(ii) Repetitive : print commands to the printer are repetitive at approximately 5 s intervals as long as the receiver remains in a balanced state.

NOTE. The print command must be set to single shot if the receiver is to be used in the REMOTE CONTROL mode. If the receiver is under manual control either mode may be used. (Printers having an auto/manual switch will normally be set to auto for repetitive mode working. For the single shot mode, and manual receiver operation, the printer should be set to manual and printout initiated by depressing the printer PRINT button only after visually checking that the receiver is in a balanced state.)

Table 4.2

Typical printer code/character relationship

Input code BCD 8	BCD 4	BCD 2	BCD 1	Character printed	Input code BCD 8	BCD 4	BCD 2	BCD 1	Character printed
0	0	0	0	0	1	0	0	0	8
0	0	0	1	1	1	0	0	1	9
0	0	1	0	2	1	0	1	0	-
0	0	1	1	3	1	0	1	1	.
0	1	0	0	4	1	1	0	0	,
0	1	0	1	5	1	1	0	1	<
0	1	1	0	6	1	1	1	0	>
0	1	1	1	7	1	1	1	1	Blank

NOTE : '0' = 0 to 0.4 V and '1' = 2.4 to 5 V.

Table 4.3

Noise receiver: remote control and printer connections

TF 2092C SK17 Pin No.	Function	Logic sense	TF 2092C SK17 Pin No.	Function	Logic sense
1 †	Receiver zero mode select	1	19	Display dB tens, b.c.d.2	1
2 †	Receiver 1 pW/channel select	1	20	Display dB tens, b.c.d.8	1
3	Not used		21	Display dB tens, b.c.d.4	1
4	Print command	pos. or comp.	22	Display = 100 dB	0
5 †	Print trigger	0	23	Display sign = minus	0
6 †	Receiver in balanced condition	1	24	Receiver out of range	optional 0 or 1
7 †	Select channel no. b.c.d.1	1	25	Not used	
8 †	Select channel no. b.c.d.2	1	26	Not used	
9 †	Select channel no. b.c.d.4	1	27	Not used	
10	Channel selected no. b.c.d.4	1	28	Not used	
11	Channel selected no. b.c.d.2	1	29	Earth	
12	Channel selected no. b.c.d.1	1	30	Not used	
13	Display = 0.5 dB	1	31*	Generator level warning	0
14	Display dB units, b.c.d.1	1	32	Not used	
15	Display dB units, b.c.d.2	1	33 †	NPR mode selected	1
16	Display dB units, b.c.d.8	1	34	Printer busy	optional 0 or 1
17	Display dB units, b.c.d.4	1	35	Not used	
18	Display dB tens, b.c.d.1	1	36	Not used	

* Required for receiver connection to printer when generator is remotely controlled from receiver only.

† Required for remote control only, not required for printer connection.

NOTE. SK17 is TF 2092C REMOTE CONTROL & PRINTER socket.

Table 4.4.

Receiver/printer interconnection

Column	Function	Origin	Logic sense	Character printed	Connect printer to TF 2092C (SK17) pin number			
					8	4	2	1
1*	Generator level warning	TF 2 091C	0 1	> Blank	'1'	'1'	'1'	31
2	Display sign	TF 2092C	0 1	- Blank	'1'	23	'1'	23
3	Display = 100 dB	TF 2 092C	0 1	1 Blank	22	22	22	'1'
4	Display dB tens	TF 2092C	BCD	0 to 9	20	21	19	18
5	Display dB units	TF 2092C	BCD	0 to 9	16	17	15	14
6	Display decimal pt.	Printer	Hard wired		'1'	'0'	'1'	'1'
7	Display = 0.5 dB	TF 2092C	0 1	0 5	'0'	13	'0'	'13'
8	Space	Printer	Hard wired	Blank	'1'	'1'	'1'	'1'
9	Channel selected no.	TF 2092C	BCD	1 to 6	'0'	10	11	12
	Print command	TF 2092C	Optional	None	Connect printer print command line to SK17 pin 4			
	Receiver out of range	TF 2092C	Optional	Red print	Connect printer red print line to SK17 pin 24			
	Printer busy	Printer	Optional	None	Connect printer busy line to SK17 pin 34			

* This function is present only when generator is remotely controlled from receiver. If an 8 column printer is used, this function is normally omitted.

NOTE. Where printer may also be used with Control Unit TK 2085 the cable should be wired in accordance with Table 4.5 of the TK 2085 instruction manual. It will also then be suitable for receiver connection to printer.

4.11 REMOTE CONTROL CONNECTIONS

4.11.1 Generator

Table 4.5 lists the pin numbering sequence of the generator REMOTE CONTROL socket. The pin functions are described below.

TF 2091C (SK18) pin numbers	Functional description
1 to 3, 5 to 9, 25 to 28	Set generator noise level in 0.1 dB steps over range -59.9 dBm to +19.9 dBm (b.c.d. format).
10, 11, 12, 13	Select band-limiting filters.
14	Removes whichever band-stop filter is selected by pins 17, 18, 19, for setting zero reference level in n.p.r. measurement mode.
15	Switches generator noise off.
17, 18, 19	Select band-stop filters nos. 1 to 6 (b.c.d. format).
31	Warns controller that send level is unattainable e.g. +33.3 dBm.
16, 20, 21	Used only for remote control from receiver.

The functional condition is maintained whilst the t.t.l. controlling signal is present with the logic sense as listed in Table 4.7.

Table 4.5

Noise generator: remote control connections

TF 2091C (SK18) Pin No.	Function	Logic sense	TF 2091C (SK18) Pin No.	Function	Logic sense
1	Send level sign = minus	0	16 †	Noise off (receiver control)	1
2	Send level dB tens, b.c.d.1	1	17*	Select b-s filters, b.c.d.1	1
3	Send level dB tens, b.c.d.2	1	18*	Select b-s filters, b.c.d.2	1
4	Not used		19*	Select band-stop filters, b.c.d.4	1
5	Send level dB tens, b.c.d.4	1	20 †	Plug sense send (to receiver)	s/c
6	Send level dB units, b.c.d.1	1	21 †	Plug sense return (from receiver)	
7	Send level dB units, b.c.d.2	1	22	Not used	
8	Send level dB units, b.c.d.4	1	23	Not used	
9	Send level dB units, b.c.d.8	1	24	Not used	
10	Select band-limiting filter no.6	0	25	Send level dB tenths, b.c.d.1	1
11	Select band-limiting filter no.7	0	26	Send level dB tenths, b.c.d.2	1
12	Select band-limiting filter no.8	0	27	Send level dB tenths, b.c.d.4	1
13	Select band-limiting filter no.9	0	28	Send level dB tenths, b.c.d.8	1
14*	Remove band-stop filters	0	29*	Earth	
15	Noise off (remote mode)	1	30	Not used	

Table 4.5 continued

TF 2091C (SK18) Pin No.	Function	Logic sense	TF 2091C (SK18) Pin No.	Function	Logic sense
31*	Generator level warning	0	34	Not used	
32	Not used		35	Not used	
33	Not used		36	Not used	

* These pins are common to remote control and control from the noise receiver.

† These pins are used for control from the noise receiver only.

NOTE : SK18 is TF 2091C REMOTE CONTROL socket.

4.11.2 Receiver

Table 4.3 (see Sect. 4.10.1) lists the pin numbering sequence of the receiver REMOTE CONTROL & PRINTER socket. The pin functions are described below.

TF 2092C (SK17) pin numbers	Functional description
1	Duplicates ZERO button on front panel i.e. causes receiver to zero to internal 1 pW/channel standard on channel power units or to zero to incoming signal on n.p.r. units.
2	Duplicates INJECT 1 pW/CHANNEL button on front panel. May be used at the end of a very long series of automatic measurements to ensure that no drift has taken place.
4	Print command, generated when display lines represent a balanced receiver state following a print trigger pulse from the controller (see pin 5 below).
5	Print trigger, may be applied at any time and causes a print command to be generated as soon as the receiver is in a balanced state (see above).
6	Receiver in balanced condition, initiated by input attenuator not having changed during six consecutive clock periods (1 s).
7, 8, 9	Select measuring channel no. 1 to 6 (b.c.d. format).
13	Display = 0.5 dB. Receiver analogue meter voltage used to produce a logic '1' when pointer indicates $\geqslant 0.5$ dB.

TF 2092C (SK17) pin numbers	Functional description
14 to 21	Tens and units (in b.c.d. format) of receiver digital display.
22	Display is 100 dB (or more).
23	Display sign is minus. NOTE. The receiver display information (pins 13 to 23) is held for a minimum of 6 clock periods (1 s), since the display is not gated through to the display lines unless the receiver has maintained a balanced state for 6 consecutive clock periods. If 1 s is not sufficient for the controller, the period may be lengthened as required by using the printer busy line (see pin 34) to inhibit changes to these lines.
24	Receiver out of range. This line is activated by either the receiver low or high limit lamps, signifying that the input signal is outside the measurement range of the receiver which is therefore unable to balance.
33	NPR mode selected. Used on TK 2085 Control Unit to prevent zeroing prior to every measurement except when n.p.r. measuring units are selected. May be used by controlling software as a partial check of correct setting of manual measuring unit selecting buttons or enables software to automatically change sequence depending upon operator choice of n.p.r. or channel power units (as in TK 2085).
34	Printer busy; inhibits changes to display lines even if receiver has reached a new balanced condition.

4.12 TEST EQUIPMENT

The following test equipment is required to carry out performance tests and realignment procedures :

(a) Multi-range d.c. voltmeter, 20 kΩ/V.

(b) Sweep generator, 10 kHz to 13 MHz, with differential detector facility; e.g., Marconi Instruments type TF 2361 and plug in TM 9692.

(c) Oscilloscope with 15 MHz bandwidth and high impedance x10 probe.

(d) RF step attenuator. 0 to 90 dB in 1 dB steps; e.g. Marconi Instruments type TF 1073A.

(e) Standardized selective level measuring set, receiver effective bandwidth between 2 kHz and 4 kHz, meter time constant approx. 1 s.

(f) Standardized power meter, (indicating true mean power); 75 Ω, for use up to 15 MHz. 1 mW range with an accuracy of 0.1 dB.

(g) Counter, 10 kHz to 12.5 MHz; e.g. Marconi Instruments type TF 2410.

(h) Electronic voltmeter, d.c. to 15 MHz; e.g., Marconi Instruments type TF 2600A.

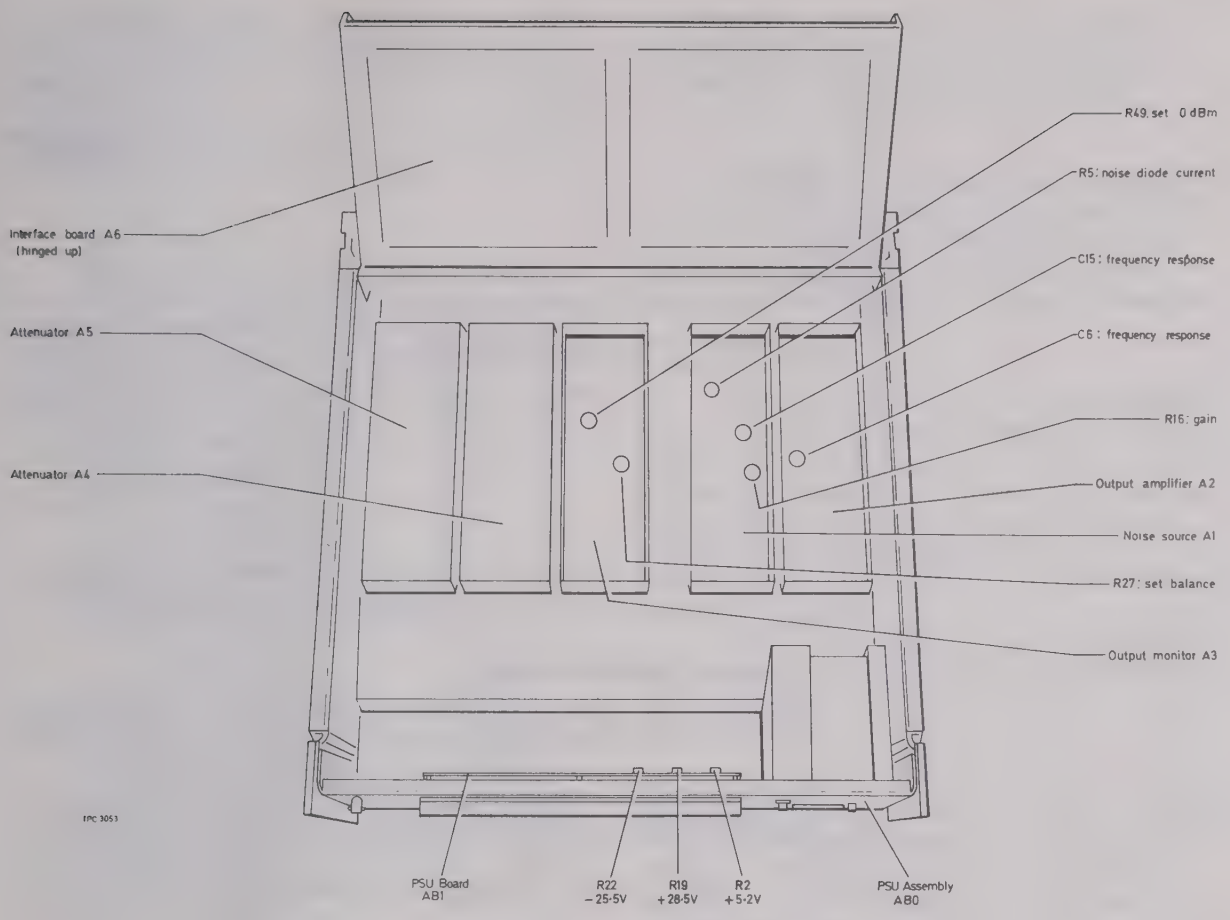


Fig. 4.7 Generator layout (control board up) showing preset controls

(j) Potentiometer, 22 kΩ.

(k) Differential d.c. voltmeter; e.g., Marconi Instruments type TF 2606.

(l) VSWR measuring test gear.

(m) AF signal source, e.g., Marconi Instruments type TF 2000.

(n) 2-pole miniature jack plug, 3.5 mm (as supplied with TF 2092C).

(p) Digital printer, e.g. GMT Model 301.

In addition to the above equipment, the receiver filter tray should be fitted with a 70 kHz filter and local oscillator.

4.13 BACK-TO-BACK TEST

The following test verifies that the test set and its filters are basically functional.

(1) On the noise generator switch IN a high-pass and a low-pass filter appropriate to the required test frequency. Switch out all band-stop filters.

(2) Set the generator output to the level in dBm given in column 3 of Table 2.7 using the OUTPUT LEVEL switches. Ensure that the generator meter is indicating zero. If not, adjust the SET ZERO control.

(3) Connect the generator OUTPUT socket to the receiver INPUT socket by means of a 75 Ω coaxial lead.

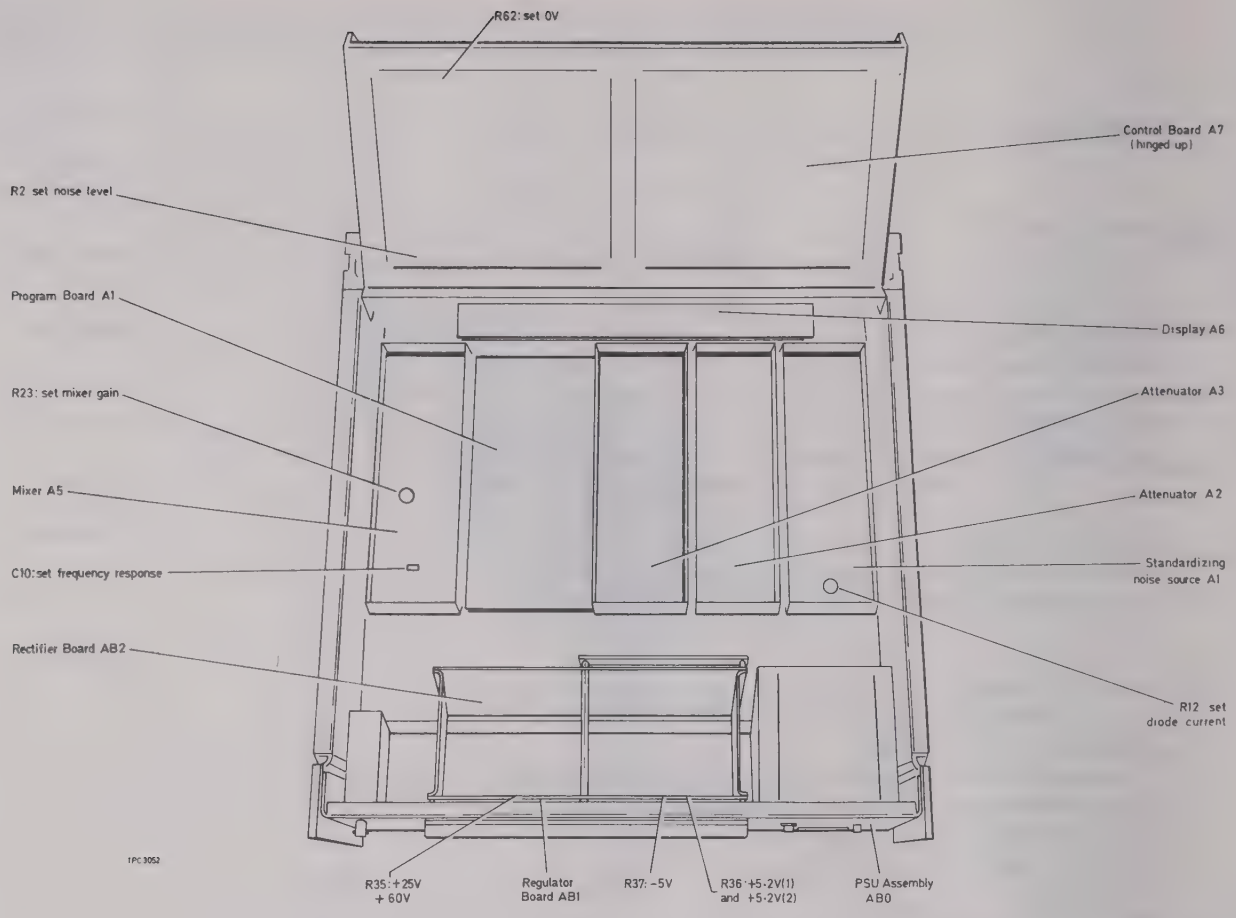


Fig. 4.8 Receiver layout (control board up) showing preset controls

(4) Switch the receiver to the channel corresponding to the required test frequency. Select NPR on the measurement units switches.

(5) Turn all EQUALIZE potentiometers and the SET ZERO control fully clockwise on the receiver. Adjust equalize level presets as outlined in Sect. 2.8.1

(6) Press ZERO, and when the receiver meter is reading on scale, turn the SET ZERO control counter-clockwise until the meter reads zero. Then release ZERO control.

(7) Switch in the appropriate band-stop filter in the generator and observe the final digital reading on the receiver to be

> 67 dB with B-type filters.
> 70 dB with A-type filters below 50 kHz.
> 75 dB with A-type filters 50 kHz and above.

(8) Switch out the band-stop filter and repeat for the remaining channels.

4.14 PERFORMANCE TESTS GENERATOR

4.14.1 Noise output and frequency response

Test equipment : items c, d, e and f.

The power output available from the noise generator will depend on the noise bandwidth, which is determined by the high- and low-pass filters used. Maximum power is +20 dBm and the levels shown in Table 2.7 should be obtainable.

Switch IN a pair of high- and low-pass filters, switch out all band-stop filters. Check that the OUTPUT LEVEL switches can be set to level in dBm given in Table 2.7, column 3.

Within the baseband of the system under test, the r.m.s. voltage of the white noise spectrum measured in a band of about 2 kHz does not vary by more than ±0.5 dB. A pair of band limiting filters may have a pass band variation of 0.2 dB measured between the outer measuring channels.

Connect the selective level meter to the OUTPUT socket and switch in a pair of band limiting filters. When measuring between the limits of the outer measuring channels, the total variation in level should not exceed 1.2 dB overall. This can be checked at various output levels and with different filters. (With A type filters, the variation could be 2 dB overall.)

Operate the NOISE-OFF switch. The output level should drop by at least 60 dB.

In addition to its uniform frequency spectrum, white noise has a random distribution of amplitudes i.e. the probability that the amplitude of the noise at any instant lies between two given levels obeys a normal Gaussian curve. Specialized analysis equipment is necessary to establish this, but a visual check can show whether operation is satisfactory.

Set the generator to any level up to +15 dBm, select band-limiting filters for maximum base bandwidth and connect the output via a 75 Ω load to an oscilloscope. With the time base off and trace centralized, a display should be observed with positive and negative peaks of equal amplitude a gradual decrease in brilliance towards each peak and no evidence of jitter, transients or clipping.

4.14.2 Output level accuracy

Test equipment : items d and f.

Output level accuracy at 0 dBm is ±0.3 dB. Additional error at other levels is ±0.5% of OUTPUT LEVEL switch setting ±0.1 dB.

Switch in a pair of band limiting filters.

(1) Measure the output level with the OUTPUT LEVEL switch set to 0 dBm and the meter set to 0, using the standardized power meter, and observing the CAUTION below.

CAUTION Do not switch any generator control or switch any filter in or out with the standardized power meter connected, since the a.l.c. circuit could cause the output to rise momentarily and overload the power meter.

(2) Functioning of the OUTPUT LEVEL switch over its entire range may be checked by monitoring the generator output with a noise receiver or selective level measuring set. Check that the change in indication on the noise receiver or s.l.m.s. follows the change in setting of the OUTPUT LEVEL switch.

NOTE. If TF 2092C is used as the monitoring device, it must be set to measure relative to 1 pW or 1 mW.

(3) When switching in different combinations of filters or selecting different output levels, the generator meter reading should remain with ±0.1 dB of its initial setting, provided that only one band-stop filter is in circuit at a time.

(4) The CHECK LEVEL lamp should come on if a level of +20 dBm or greater is selected, if the meter is off scale or if the OFF switch is operated.

(5) If the above checks are unsatisfactory refer to Chap. 5.

4.14.3 Output impedance and return loss

Test equipment : item l.

Output impedance is 75 Ω and return loss greater than 20 dB when the output level is set to 0 dBm or below.

When set to -10 dBm or below, the return loss should be greater than 26 dB.

4.14.4 Programming inputs

In order to check these, it is necessary to provide suitable inputs to the remote control socket and to have the programmable Filter Unit TK 2087 fitted.

Sect. 4.11.1 gives the required inputs for controlling all the generator functions.

4.15 PERFORMANCE TESTS—RECEIVER

4.15.1 Sensitivity

The sensitivity is specified as being better than -130 dBm/kHz with 'B' type filters, and better than -120 dBm/kHz with 'A' type filters.

The actual digital result to be measured on the receiver is arrived at by allowing 5 dB which can be read on the meter after the input attenuator is at zero and from the fact that the receiver is calibrated to read power in a 3.1 kHz channel (giving a 5 dB difference).

Set the TRANSMISSION LEVEL to 0 dBr. Set all EQUALIZE potentiometers and the SET ZERO control fully clockwise. Select 1 mW, METER x2 and CHANNEL 1 push-buttons, ensuring that all others are out. Press ZERO, wait until the meter is reading within ±0.5 dB of zero, and then release ZERO.

Check that the display goes to -120 dBm or less (less = more negative), that the low level warning lamp comes on, and that the meter pointer is reading positive with the pointer fully over to the end stop.

Check the remaining channels in the same way. With 'A' type filters, the display must go to -110 or less.

4.15.2 Bandwidth

Test equipment : item e.

Effective receiver bandwidth is nominally 2.2 kHz and is determined by the bandwidth of the l.f. amplifier (mixer unit terminals 4 and 5), slightly modified by the bandwidth of the band-pass filter. Since the l.o. frequency is at the centre frequency of the r.f. pass band, the bandwidth of the l.f. amplifier is only 1.1 kHz i.e. half the receiver pass band. The receiver bandwidth may be determined using a signal generator to plot the relative sensitivity in the neighbourhood of the frequency selected.

4.15.3 Control functions and panel controls

High level lamp

Test equipment : items d and e.

Turn all EQUALIZE potentiometers fully clockwise.

Switch in 70 kHz band-pass filter.

Connect the generator output of the s.l.m.s. to the receiver input. Set the output level to approximately -10 dBm.

Set the r.f. step attenuator to 0 dB.

Receiver settings : 1 mW button IN, remaining buttons OUT
TRANSMISSION LEVEL = 00 dBr
SET ZERO fully clockwise
70 kHz filter selected

Adjust the frequency of the oscillator between 69 and 70 kHz until the receiver display reaches a maximum. Very slowly increase the oscillator output level until the HIGH level warning lamp comes ON. Check that the analogue display reads about +1 dB.

Auto zero

Switch to NPR and zero the receiver. Check that display reads 0 dB; HIGH level lamp still ON; meter still reads +1 dB. Back off the meter reading to zero by reducing the oscillator output level. Increase the attenuation quickly to 30 dB and check that the display reads between 29 and 31 dB. Reduce attenuation to 0 dB. Increase the attenuation again until it reaches 18 dB and check that the digital and analogue displays read zero.

Attenuator and LOW level lamp

Reduce the attenuation to 0 dB and press 1 pW button. Check that display reads 0 dBrn.

Apply 80 dB attenuation in steps of 20 dB. Check that the display falls in 20 dB steps ±1 dB to -80 dB ±1 dB.

Reduce the oscillator output by 30 dB and increase the attenuation very slowly in 1 dB steps, noting that when the digital display reads -119 dBrn and the analogue meter reads about +1 dB, the LOW level lamp comes ON.

HOLD, analogue meter, and RECORD output

Test equipment : items a and n.

Connect a noise generator to the receiver input. Switch in a pair of band-limiting filters, switch out all band-stop filters and set the generator output to -10 dBm. Switch receiver to NPR and allow it to stabilize. Select HOLD and METER x2 and adjust the SET ZERO control for zero meter reading.

Connect the multimeter on the 10 V range to the RECORD output socket using the jack plug. The output should be approximately 1 V.

Decrease the generator output level in 1 dB steps to -15 dBm. Check that the meter follows the 1 dB steps and that the multimeter reads 0 V when the meter reads -5 dB.

Increase the generator output to 0 dBm. Check that the record output is +3 V approx.

Decrease the level to -5 dBm. Check that the meter reads +5 dBm and that the record output is 2 V approx.

Decrease the level to -10 dBm in 1 dB steps and check the meter calibrations.

Arithmetic and front panel controls

Change the measurement units switch to 1 pW and see that display reads 0 dBm. Check that the display follows the TRANSMISSION LEVEL settings exactly when the switch is incremented from 00 to 49. Check that dBrn0 is displayed when the transmission level is not 00.

Disconnect the input to the receiver and set TRANSMISSION LEVEL to 0 dBr. Ensure that all push-buttons are OUT. Press 1 mW, INJECT 1 pW/CHAN and ZERO. Adjust for zero meter reading and release the ZERO button; check that the display reads -90 dBm. Press HOLD and check the push-buttons, display and arithmetic functions in Table 4.6.

Table 4.6

Display and arithmetic functions

Transmission level	Push-button in	Measurement result		
		Digital	Meter	Units
0 dBr	1 mW	-90	0	dBm
	1 mW, psoph	-92	+0.5	dBm psoph
	1 pW, psoph	-2	+0.5	dBrn psoph
	1 pW	0	0	dBrn
	1 pW, C-Mess	-2	-0.5	dBrnC
-1 dBr	1 pW, psoph	-1	+0.5	dBrn0 psoph
	1 pW	1	0	dBrn0
	1 mW	-89	0	dBm0
	1 mW, psoph	-91	+0.5	dBm0 psoph
	NPR	0	0	dB

* The analogue meter is displaying a random noise signal and the reading will be erratic. The mean level only should be observed.

4.15.4 Input impedance

Test equipment : items c and l.

Input impedance is 75 Ω with a return loss greater than 20 dB for input levels exceeding -100 dBm/channel. Connect generator output to receiver input. Select one channel and zero the receiver with 1 mW unit selected. Adjust the generator level, with the band-stop filter switched in, until the receiver display reads -100 dBm. Press the HOLD control and remove the input signal. Measure the return loss at the input socket which should be greater than 20 dB. Select INJECT 1 pW/CHAN. The return loss should again be greater than 20 dB.

4.15.5 Standardizing noise source

White noise is generated over the band 10 kHz to 13 MHz. Output level is -90 dBm per 3.1 kHz bandwidth (-95 dBm per 1 kHz bandwidth).

The noise source may be checked functionally by comparison with an external noise source of known power density, or by checking that the receiver can be set up to measure absolute noise as in Sect. 2.10. If a fault is suspected, see Chap. 5.

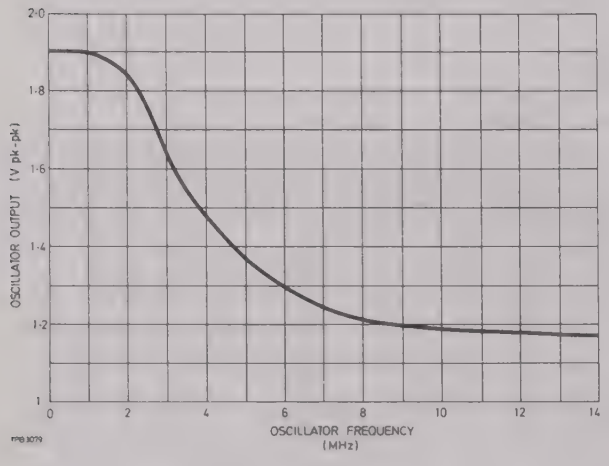


Fig. 4.9 *Local oscillator output measured at the monitoring socket*

4.15.6 Local oscillator

Test equipment : items c and g.

When the local oscillator boards are fitted in the receiver, their output levels and frequencies can be monitored at the rear panel socket. The level measured will depend on the method used as the oscillators have a high impedance output. Using a low capacitance probe (x10, 10 MΩ, 30 pF) and an oscilloscope, the levels in Fig. 4.9 should be measured ±25%. Do not load the OSCILLATOR OUTPUT when setting up equalization.

4.15.7 Program board (when fitted)

Test equipment : items a and p.

Connect the printer to REMOTE CONTROL AND PRINTER socket (SK17) on the rear panel. Patch the program board for repetitive print and to suit the printer - see Sect. 4.8. Switch the printer to manual operation. For various readings on the receiver, check that the printer prints out the same numbers as displayed on the receiver together with the channel number selected. Switch the printer to automatic operation and check that a printout occurs approximately every five seconds whilst the receiver display remains constant. Remove the input to the receiver; check that the LOW INPUT warning light comes on and that the printer will print in red.

Monitor the voltages at pins 17, 18 and 19 of SK18 (marked GENERATOR TF 2091C). As channels 1 to 6 are selected, check that the logic levels follow the correct pattern. Operate the NOISE OFF switch and check the voltage at pin 16 - see Sect. 4.9 for the correct logic signals. Alternatively link the receiver to the generator with cable 43129-144X and check that the correct functions are controlled.

4.15.8 Receiver programming inputs

Switch the receiver to REMOTE operation. Check that the REMOTE lamp lights and that all filter indicating lamps are out. Apply suitable inputs for channel selection, inject 1 pW/ch and zero and check that the correct functions are controlled - see Sect. 4.11.2.

Chapter 5

Repair

5.1 INTRODUCTION

This chapter contains information for use in fault finding and realignment.

NOTE. See Sect. 4.1 for notes regarding performance limits and test methods and for precautions in handling semiconductors.

In case of any difficulty, please write or phone the Marconi Instruments Service Division (see address on back cover) or nearest representative, quoting the type and serial number on the data plate at the rear of the instrument. If the instrument is being returned for repair, please indicate clearly the nature of the fault or the work you require to be done.

5.2 VOLTAGES

The voltages given on circuit diagrams and in the text are those which may be expected on a typical OA 2090C at a mains input of 230 V, using a 20 kΩ/V meter, and are d.c., relative to chassis, unless otherwise indicated.

5.3 REALIGNMENT—GENERATOR

Test equipment required for the procedures in this section is listed in Sect. 4.12. Figs. 4.7 and 4.8 will assist in the location of preset controls.

5.3.1. Power supply: AB0, AB1

Test equipment : items a and k.

Preset controls : R2 sets +5.2 V
R19 sets +28.5 V
R22 sets -25.5 V

Tables 5.1 and 5.2 give the voltage levels to be expected at the quoted test points.

Should it be necessary to replace components on the power supply, the rear panel of the instrument may be hinged down as follows.

Switch the generator off. Remove the filter unit from the instrument. Remove generate top and bottom covers. From the underside of the chassis, release the two screws securing the mains transformer. Hinge the rear panel down by removing the top screws and slackening the bottom screws fixing the panel.

Table 5.1

Rectifier output voltages

Terminal No.	Regulated voltage line	Approx. d.c. volts at nominal supply input
6	+5.2 V	+14 V
12	+28.5 V	+49 V
Negative end of C5	-25.5 V	-52 V

Table 5.2

Regulated output voltages

Terminal No.	Regulated voltage line	Tolerance (differential voltmeter)	Typical load current	Short circuit current limit
10	+5.2 V	±20 mV	940 mA (9 filters selected)	< 1.55 A
8	+28.5 V	±50 mV	220 mA	< 310 mA
11	-25.5 V	±50 mV	90 mA	< 100 mA

The generator will operate normally in this condition. Access to the underside of board AB1 may be gained by removing five of the six screws holding the heat sink (leave the top centre screw in).

NOTE. If the supply voltages are significantly below their correct value, this could be due to operation of the current limit protection circuits. Should this be suspected, disconnect the appropriate supply and substitute a load resistor to draw the nominal load current given in Table 5.2.

5.3.2. Interface board: A6

Test equipment : item a.

Filter selection

Fit Filter Unit TK 2087 into the noise generator. If this is not available, continue with tests but connect a 240 Ω, $\frac{1}{4}$ W resistor across the test meter terminals. Press all filter selection buttons in. Measure the voltages at pins 21, 22, 24, 28, AA, AC, AD, AE, AH, AJ on the large edge connector SK15. These should all be greater than 4.6 V. Measure the voltages at pins 23, 25, 26, 27, 29, 30, Y, Z, AB, AF on SK15. These should all be less than 0.5 V. Press all filter selection buttons out. Check that at the first set of pins the voltage is less than 0.5 V and at the second set, greater than 4.6 V.

Level selection

Tables 3.1 to 3.4 will be useful in fault finding in this area. As a preliminary check, measure the input voltages to the board from the thumbwheel switch. These should correspond to the b.c.d. code for the level selected where '0' = chassis potential and '1' is open circuit - typically measured as 1.5 V at the t.t.l. gate input.

Points to bear in mind are (i) that when the output level is set to +5.0 dBm the attenuator control lines to A4 and A5 should all be at logic 0 and (ii) that for selected levels of 0 dBm and below, the 5 dB pad control line should be at logic 1 with the sum of the other pads in (at logic 1) equalling the number set.

Both level and filter selection circuits may be tested with signals from the remote control socket by switching to remote operation.

5.3.3. Output attenuators: A4 and A5

Test equipment : items d and e.

Remove PL20 from the output monitor A3. Set the generator OUTPUT POWER switch to +5.0 dBm. Set the s.l.m.s. to 100 kHz and its output level to 0 dBm. Connect the equipment as shown in Fig. 5.1.

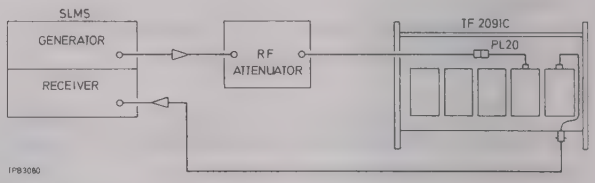


Fig. 5.1 Test gear connections for attenuator checks

Set the standard attenuator to 70 dB, and adjust the s.l.m.s. receiver for a zero meter reading. Tune the s.l.m.s. to 13 MHz and note the new reading which must be less than 0.3 dB. Make allowance for the frequency response of the s.l.m.s. and r.f. attenuator.

Check all the attenuator pads using the data in Table 5.3. Make allowance for the attenuation errors of the r.f. attenuator to derive the figures in column 4. Operate each attenuator pad a few times to check the stability of the reading. Variations of greater than ±.05 dB are unacceptable and could be caused by faulty relays in the attenuator. Replace PL20.

5.3.4 Output amplifier: A2 and Filter Unit TK 2087 or TK 2087/1

Test equipment : items a, b, c and e.

Preset control : C6 adjusts frequency response.

As the amplifier has an output impedance of approximately 39 Ω, it is best checked in conjunction with the filter unit. First of all check the filter unit for continuity with the multimeter.

Fit the filter unit into the generator without filters. Remove PL1 from the output of the noise source and PL4 from the input to the output amplifier. Check the resistance between centre pins of the plugs, which should be less than 1.2 Ω with filter push buttons 6 - 9 selected and less than 0.6 Ω with the buttons out.

Table 5.3

Attenuator check limits

OUTPUT POWER switch setting	Attenuator pad checked (dB)	RF attenuator setting (dB)	SLMS receiver meter reading (dB)
+4.0	1	69	±.1
+3.0	2	68	±.11
+1.0	4	66	±.12
0.0	5	65	±.13
-8.0	8 + 5	57	±.17
-10.0	10 + 5	55	±.18
-20.0	20 + 5	45	±.23
-40.0	20 + 20 + 5	25	±.33
-59.0	All pads in	6	±.42

Replace PL4. Disconnect PL5 from the output of the amplifier and PL6 from the input of the output monitor. Check the resistance between the centre pins of the plugs, which should be 35 Ω with filter push buttons 1 - 6 selected and 35 Ω with the buttons out.

Replace PL5 and PL6 and remove the filter unit.

To check frequency response using the TK 2087, fit a high-pass filter in position 6, a low-pass filter in position 9 and a band-stop filter in position 1. Remove the locking bar and switch all filters out using their rocker switches. Select only filters 1, 6 and 9 with the push button switches.

If using the TK 2087/1, fit three band-limiting filters and three band-stop filters. Again, switch all the filters out.

Replace the filter unit in the generator and set the OUTPUT POWER switches to +5.0 dBm.

Set the s.l.m.s. generator output to approximately -12.5 dBm and the frequency to 100 kHz. Connect the signal to PL1 and monitor the output socket of the noise generator using the s.l.m.s. receiver and the oscilloscope. Adjust the input signal level until clipping is observed on the output waveform. The output level must then be greater than +27.5 dBm.

CAUTION Do not maintain this output level for longer than necessary as damage to the amplifier could result.

Adjust the input signal to -20 dBm and measure the amplifier gain, which should be 39 to 41 dB. At 7 kHz, the amplifier gain should be within ±0.15 dB of the 100 kHz figure.

Disconnect the s.l.m.s. and oscilloscope, and connect the sweep generator to measure frequency response up to 13 MHz. Adjust the sweep generator output so that the input signal to the amplifier is -40 to -30 dBm. Adjust C6 for a response flat to within ±0.5 dB from 100 kHz to 13 MHz with the box lid on. If this is not possible, the value of C4 may be altered slightly.

With the TK 2087 fitted, operate each filter selection button several times and check that the response returns to the same shape. Excessive and intermittent variations indicate a faulty relay in the filter unit.

5.3.5 Output monitor: A3

Test equipment : items d, e and k.

Preset controls : R21 sets bridge balance.
R27 sets monitor accuracy.
R49 sets meter zero.
C2 adjusts overall frequency response.
C24 adjusts +10 dBm range.
C8 adjusts +20 dBm range.

Fit the filter unit, connected as in Sect. 5.3.4. Connect all internal plugs as for normal operation except PL1. With the differential voltmeter connected between tag 3 and earth, and with no input signal, adjust R21 for zero reading on the voltmeter.

Table 5.4

Limits of output monitor reading

RF attenuator setting (dB)	TF 2091C OUTPUT POWER setting (dBm)	TF 2091C meter reading dB at 100 kHz	TF 2091C meter reading at 10 MHz (relative to 100 kHz)	Adjust trimmer
15	0.0	0		
15	5.0	±.13	-.15	C2
10	10.0	±.15	-.45	C24
5	15.0	±.18		
0	19.9	+.3, -.1	-.5	C8

Set the s.l.m.s. to 100 kHz and the output level to -21 dBm. Connect this signal to the r.f. attenuator set to 15 dB and then to PL1.

Connect the OUTPUT socket of the TF 2091C to the input of the s.l.m.s. receiver. Adjust the input signal level until the receiver reads +4 dBm with the TF 2091C OUTPUT POWER set to +5.0 dBm. Adjust R27 until the TF 2091C meter reads -0.5 dB.

Operate the OUTPUT POWER switch from +4.0 to +5.0 dBm in .1 dB steps and check that the meter moves from +.5 to -.5 in approximately .1 dB steps. With the output set to +4.0 dBm, readjust R27 for zero meter reading.

Check the ranges of the monitor against the limits in Table 5.4.

Reset the r.f. attenuator to 15 dB and the TF 2091C output to +5.0 dBm. Change the s.l.m.s. frequency to 10 MHz and adjust the capacitors C2, C8 and C24 to the levels given in Table 5.4. In all the above checks make allowances for the errors in attenuation of the standard attenuator. These tests prove that the monitor circuit is working normally. Final setting up can only be done after the noise source (A1) is known to be working properly.

5.3.6 Noise source: A1

Test equipment : items a, c, e and j.

Preset controls : R5 sets diode current.
R16 sets output level.
C15 adjusts frequency response.

The noise source module contains four main sections :

(i) the noise diode and its biasing network,
(ii) a wide band amplifier,
(iii) a d.c. amplifier for the a.l.c. loop,
(iv) the meter limits detector.

The last two are powered from a ±15 V line derived in the output monitor (A3). Check that this is present before proceeding with further tests. Noise diodes are extremely stable and R5 should only be adjusted when all other possible faults have been eliminated.

The wide band amplifier section is normally contained within the a.l.c. loop. To check its performance it is necessary to disable the a.l.c. loop as follows :

Switch off generator.

Disconnect links between tags 3-4 and 12-13.

Connect the potentiometer, resistor and leads as shown in Fig. 5.2.

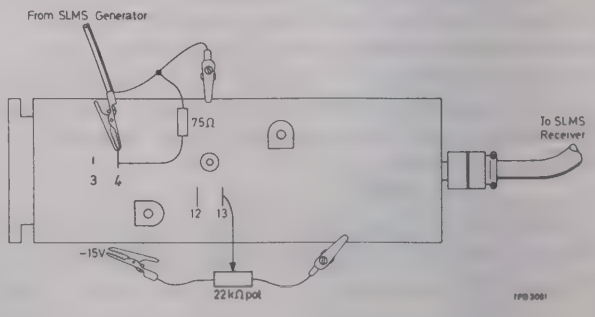


Fig. 5.2 Test set-up for noise source

Switch on generator.

Set the amplifier gain to maximum by turning R16 fully clockwise and adjusting the 22 kΩ potentiometer for maximum negative bias at tag 13.

Connect the oscilloscope and selective level meter to the OUTPUT socket (75 Ω impedance) and set the signal source to 100 kHz with an output level of approximately -45 dBm.

Adjust the level until the waveform starts to be clipped.

The output level should then be not less than +2 dBm.

Set the input level to -50 dBm and measure the amplifier gain, which should be between 49.5 and 52 dB. Turn R16 fully counter-clockwise; the gain should be between 33 and 38 dB. Set the voltage at tag 13 to 0 V; the output level should drop by at least 45 dB.

Disconnect the input lead and 75 Ω resistor. Link tags 3 and 4 and set the selective level meter to 100 kHz. Adjust the 22 kΩ potentiometer to give maximum noise output and then readjust it until the noise level drops by 6 dB. R16 must now be adjusted to give an output level of -47 dBm/3.1 kHz.

Adjust the output level to -60 dBm using the bias potentiometer. Tune the level meter to 13 MHz and adjust C15 until the level is again -60 dBm. If this is not possible C16 may be changed to another value.

Check the total variation in frequency response of the noise between 6 kHz and 13 MHz which should be less than 0.5 dB. If necessary slightly adjust C15. The frequency response could be checked with the s.l.m.s. generator connected as in Fig. 5.2 if trouble is experienced.

If the response test is satisfactory, it is likely that the noise diode is faulty or that its operating current has changed. Noise diodes are always biased at a dip in noise output level. As the current has been previously set and any drift is likely to be slight, only slight adjustment should be attempted. Monitor the noise source output with tags 3 and 4 linked and adjust R5 very slightly to set the noise output to a minimum.

NOTE. There are several dips in noise output on most diodes. Only one of these is the correct setting.

When fitting a replacement diode, the current may be monitored with a voltmeter connected across tags 3 and 5. For the value of current given in mA, read volts on the voltmeter.

5.3.7 Overall tests and setting up (involving more than one sub-unit)

Test equipment : items a, d, e and f.

Replace all internal links and leads for normal operation of the generator.

Fit the following filters into the Filter Unit TK 2087 or -/1 : 60 kHz high-pass, 300 kHz, 4100 kHz and 12360 kHz low-pass (or nearest available frequencies).

Switch in the 12360 kHz low-pass filter and set the output level to 0 dBm. Adjust the SET ZERO control approximately to the centre of its range and set A3R49 for a zero meter reading. Monitor the output power and adjust A3R27 until the output is 0 dBm.

Check the frequency response of the noise output (see Sect. 4.14.1). C6 in the output amplifier may be adjusted if necessary.

Check the output power accuracy at 0, +10 and +19.9 dBm output levels on narrow, medium and wide bandwidths using the filters specified previously. Should any of these be outside the limits, readjustment of A3R27, C2, C24 or C8 may be necessary. R27 will affect all readings and C2, C24 and C8 will have most effect on the wide bandwidth. Proceed by adjusting the lower output levels first. Overall frequency response is affected by C2. C24 affects the accuracy of levels above +5.1 dBm and C8 affects the accuracy of levels above +15.1 dBm.

5.4 REALIGNMENT—RECEIVER

5.4.1 Power supply: AB0, AB1, AB2

Test equipment : item a.

Preset controls : R35 sets +60 V and +25 V.
R36 sets +5.2 V (1) and +5.2 V (2).
R37 sets -5 (see Fig. 4.8).

The rear panel can be hinged down to gain access to the power supply terminals. The receiver will operate with the rear panel hinged down :

Remove the filter tray from the instrument.
Remove the top and bottom covers from the instrument.
From the underside of the chassis, release the two screws clamping the mains transformer and the screws securing the power supply boards.
Replace the filter tray.
Hinge the rear panel down by removing the upper three screws and slackening the lower screws fixing the panel.
Switch the receiver ON.

NOTE. If the supply voltages are significantly below their correct value, this could be due to operation of the current limit protection circuits Should this be suspected, disconnect the appropriate supply and substitute a load resistor to draw the nominal load current given in Table 5.6.

Table 5.5

Rectifier output voltages, board AB2

Terminal No.	Regulated voltage line	Approx. d.c. volts at nominal supply input
(rel. to 1)	+60	+70
2	-5	-13
5	+5.2 (2)	+14
6	+5.2 (1)	+13
7	+25	+39

The rear panel heat sink may be swung away to expose the printed side of board AB1 by removing five of its six fixing screws (leave the top centre screw in). Replace one screw to make a good earth to the s.c.r. bracket.

5.4.2 Standardizing noise source: A1

Test equipment : items a and e.

Preset controls : R12.

R12 sets the current through the noise diode. The required bias current depends upon the particular noise diode and should be within the limits 300 μA to 2 mA. If the diode is operated with any other bias current it will not produce white noise. Therefore, unless it is quite certain that the instrument is faulty in this respect, no adjustment should be made to this preset control.

Table 5.6

Regulator output voltages, board AB1*

Terminal No.	Regulated voltage line	Tolerance (diff. voltmeter)	Typical load current	Short circuit current limit
16	+5.2 (1)	±50 mV	30 mA	80 mA
22	+5.2 (2)	±50 mV	1.8 A	600 mA
17	-5	±50 mV	80 mA	130 mA
21	+12	11.5 V to 13 V	50 mA	30 mA
20	+25	±50 mV	120 mA	350 mA
19	+60	±5 V	2 mA	Not protected

* measured relative to terminal 23 on board AB1 except where otherwise stated.

Performance may be checked using a selective level meter. Select INJECT 1 pW and connect the level meter to PL7. The noise power density measured at 100 kHz should be -90 dBm per 3.1 kHz (-95 dBm/kHz), and the variation of power density between 10 kHz and 13 MHz should not exceed 0.5 dB. Only if the noise power density at 100 kHz differs from nominal by more than 0.5 dB should R12 be minimally adjusted to give a minimum power density. If necessary R7 and C5 may be selected to obtain the nominal power density and a flat frequency characteristic.

5.4.3 Attenuators

The tests outlined in Sect. 4.15.3 will check that the attenuator is functional. Because of the difficulty of setting a particular value of attenuation in the instrument, it is necessary to remove the attenuator for comprehensive tests. If a suitable test jig is made up, the attenuator pads can be checked and should be within 0.5% ±.1 dB of their nominal value at all frequencies up to 13 MHz (relative to the 'all pads out' condition at the same frequency).

See Sect. 3.2.2 and Table 3.1 for details of attenuator operation.

5.4.4 Mixer unit: A5

Test equipment : items c, d, e, h and m.

Preset controls : R23, C10.

The mixer unit consists of a wide band amplifier (TR1-3) with a non-adjustable gain of 32.5 dB, a mixer (IC1) with a voltage conversion gain of approximately 10 dB and an l.f. amplifier (IC2 and IC3) with a gain of 40 dB at mid-band. The overall gain of the circuit from input (SK10) to output (terminals 4 and 5) is 82.5 dB set by R23. It is difficult to measure directly the gain of the mixer. Because of the high level of local oscillator signal at the mixer output (board terminal 6), the gain is measured at the unit output.

To check gain at 100 kHz, connect the s.l.m.s. generator to SK10 with an 82 Ω load across the mixer unit input. Remove the link across board terminals 2 and 3. Set the generator to 100 kHz and -50 dBm; the level at the output terminal 4 should be -17.5 ±1 dBm into 75 Ω. (To check the overload characteristic, increase the input, at 100 kHz, so that the amplifier output is +3 dBm and, using an oscilloscope, ensure that no obvious distortion is present.)

The amplifier frequency response should be flat to better than 1 dB from 10 kHz to 13 MHz when driven from a source impedance of 750 Ω. C10 is the preset but should only be adjusted with a specialized test fixture.

Replace the link to board terminals 2 and 3.

To check the l.f. amplifier, connect the mixer unit output to its normal coaxial cable and set all EQUALIZE controls and the SET ZERO control fully clockwise. Remove the link from board terminals 6 and 7 and connect the a.f. signal source to board terminal 7 via a 3.3 kΩ resistor. An input applied at board terminal 7 of approximately 1 mV r.m.s. at a frequency of 500 Hz should give 100 mV at the output pin 4. 3 dB cut-off frequencies occur at approximately 40 Hz and 1100 Hz. The roll-off above 1.1 kHz is at the rate of 24 dB per octave and is determined by the first and second stages which are coupled stages of a low-pass active filter.

Reconnect the link between board terminals 6 and 7.

To set overall gain and check mixer conversion gain, connect the s.l.m.s. generator to SK10 via the attenuator. Connect an 82 Ω load across the mixer input close to SK10. Keep the 75 Ω cable from the attenuator short.

Fit a 70 kHz oscillator board into the Filter Unit TK 2086 and fit this into the receiver.

Set the attenuator to 83 dB. Set the signal to 70.5 kHz and the output level to 0 dBm.

Switch in the 70 kHz channel from the receiver front panel. Connect the voltmeter to the mixer unit output and tune the signal source around 70.5 kHz for a peak on the voltmeter. Adjust R23 such that the voltmeter reads approximately 260 mV.

NOTE. If a 70 kHz channel is not available, use the nearest frequency and adjust the signal source for a frequency approximately 500 Hz away from the actual oscillator frequency.

5.4.5 Filter Unit TK 2086

Test equipment : items a and c.

Remove PL8 from the output of the attenuator A3 and PL10 from the mixer input. Connect a back-to-back BNC connector between each input and output lead in the filter unit and fit an oscillator board at around 70 kHz into position 1. Replace the filter unit in the main instrument and connect the oscilloscope to SK16 on the rear panel, the OSCILLATOR OUTPUT socket. Select positions 1 to 6 in turn and measure the resistance between the centre pins of PL8 and PL10. This should be less than 0.3 Ω. Check the oscillator output in position 1, which should be approximately 1.7 V pk-pk. Fit the oscillator into positions 2 to 6 and check that the same level is measured.

5.4.6 Control circuit: A7

Test equipment : items h, k and m.

Preset controls : R2 and R62.

Disconnect the lead to edge connector pin B on the control board. Connect the a.f. signal source to this point with the frequency set to 400 Hz approximately.

Fit the filter unit and turn all EQUALIZE potentiometers and the SET ZERO control fully clockwise. Select the CHANNEL POWER : 1 pW button, depress HOLD and select ±2.5 dB meter range. Connect the a.c. voltmeter to TP1 and the differential voltmeter to TP4. Use TP3 as the earth connection for all the measuring instruments.

Adjust the signal source for a reading of 34 mV on the a.c. voltmeter. Note the d.c. reading at TP4. Increase the signal source output to give 86 mV at TP1. Subtract the new reading at TP4 from the original reading; this should give a result of 810 mV ±5%. R18 may be adjusted to obtain this condition. This will be necessary if IC4 has been replaced.

Adjust the signal source for 52 mV at TP1 and check that the meter reads zero and that there is 0 V at TP4. If necessary adjust R62 to achieve this. Re-check that the correct change of 810 mV on TP4 is maintained. Replace R43 and R46 on A7 by 100 Ω potentiometers so that their values may be adjusted. (The potentiometers may be soldered to the tracks on the underside of the A7 board.) Set both potentiometers to maximum value. With 400 Hz source still connected, select NPR and operate ZERO button. Adjust the input level so that the meter pointer is just against -1 dB mark on the ±2.5 dB meter scale, release HOLD button and adjust R46 slowly until attenuator just starts to change (audible operation of relays).

Operate HOLD button and reset the input so that the meter pointer is just against +1 dB mark. Release the HOLD button and reduce R43 until attenuator again starts to change. The potentiometer values are now measured and replaced with fixed resistors. The settings may be re-checked by observing the meter pointer at the instant when the attenuators change. The correct meter pointer positions are indicated below.

Operate the HOLD button and adjust the signal source so that the meter reads zero, then momentarily depress the ZERO button to make the digital display read 0. Select C-MESS and PSOPH WEIGHTING to check that the meter reads +0.5 dB and -0.5 dB respectively. Release both WEIGHTING buttons and turn the SET ZERO control fully counter-clockwise. The meter should read approximately -2.5 dB.

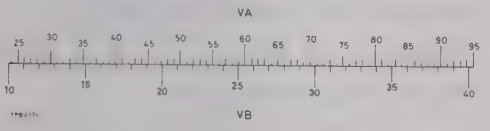
There is no simple method of checking the digital circuitry without special test equipment. If a fault is suspected, depress the HOLD button at several different readings of the digital display and for each case check through the circuit using the information from Sect. 3.2.7.

Remove a.f. signal source from pin B and replace with the lead previously removed. Fit a 2438 kHz filter and oscillator into the filter tray and select 2438 kHz. Connect the a.c. voltmeter with its sensitivity set to 52 mV to TP1.

Note ...

It may be necessary to parallel the input of the a.c. voltmeter with a 47 μF electrolytic capacitor to help stabilize the random fluctuations in the reading.

Turn the SET ZERO and EQUALIZE potentiometers fully clockwise, select the measurement channel and press '1 mW'. All remaining buttons are out. Zero the receiver; neither the HIGH or LOW INPUT-LEVEL lamps should be lit. Record the average reading on the voltmeter (this is VA on the scale below).



Release ZERO and adjust R2 until the average reading on the voltmeter is equal to VB. Disconnect test equipment.

5.4.7 Program board

See Sect. 4.15.7 and 4.15.8 for tests and Sect. 3.2.8 for circuit details.

5.5 FAULT FINDING

Back-to-back test

This test - see Sect. 4.13 - is an overall test of noise generator, noise receiver, band stop and band-pass filters, and oscillators, and can be used for preliminary fault location.

Faults

The following tables list some of the possible fault conditions which may be encountered and indicate an appropriate procedure to locate the fault. The tables should be used in conjunction with the circuit diagrams at the rear of the manual and with the tests detailed in Sect. 5.3.

Table 5.7

Noise generator

Symptom	Possible fault area	Method of fault location
No pilot light.	Mains input. Blown mains fuse.	Check mains connection. Check for short circuit.
Zero output and meter reading - f.s.d.	NOISE ON/OFF switch. Filter switches. Internal connections. Power supply.	Check switch position. Operate each push button switch in turn and then each mechanical filter switch. Examine. Check voltages on sub-units.
Meter indication but zero output.	Attenuators open circuit.	Check functionally.
Meter indication too high.	Faulty SET ZERO control. ALC circuit. Sticking meter.	Check continuity. Check sub-units and continuity of connections between units. Check meter.
Poor back-to-back n.p.r.	Band-stop filter. Filter unit.	Check characteristics. Check correct operation of relays.
CHECK POWER LEVEL warning lamp on or incorrect output level.	OUTPUT POWER switch. Interface board.	Check code given by switch. Faulty decoding circuitry.

Table 5.8

Noise receiver

Symptom	Possible fault area	Method of fault location
No pilot light.	Blown mains fuses.	Check for short circuit.
Blank digital reading and zero meter reading.	Blown fuse.	Check for short circuit.
	Power supply.	Check for voltages on sub-units.
	Meters.	Check for open circuit.
	LF connections.	Check continuity from SKT13 pin A to SKT13 pin M.
	Mixer unit.	Functionally check.
Lack of sensitivity on all ranges.	INJECT 1 pW/CHAN. switch.	Check switch for required operation.
	EQUALIZE LEVELS presets.	Turn fully clockwise.
	Attenuator.	Check attenuator (see Table 3.1 and Sect. 5.4.3).
	Internal connections.	Examine leads to band-pass filters. Check that frequencies of local oscillators and band-pass filters correspond.
	Mixer and l.f. amplifier units.	Functionally check.
Lack of sensitivity on one range only.	EQUALIZE LEVEL presets.	Turn fully clockwise.
	Local oscillator.	Check frequency and level at local oscillator socket.
	Internal connections.	Examine leads to band-pass filter. Check that frequency of local oscillator and band-pass filter correspond. Check unit band-pass filter is connected correctly.
	Filter unit switches.	Check with oscillator and filter in another position.
	Band-pass filter.	Check pass band insertion loss - see Sect. 3.2.4.
Poor back-to-back n.p.r.	Attenuators.	Functionally check.
	Local oscillator.	Check frequency at local oscillator socket.
	Band-pass filter.	Check characteristics.
Receiver taken a long time to balance or does not balance at all.	Attenuator giving intermittent results.	Check attenuator.
	Oscillator noise level high.	When LOW INPUT LEVEL lamp comes on, check meter is off scale on x2 range. Check adjustment of A7R7 (see Sect. 5.4.6).

Chapter 6

Replaceable parts

Introduction

The main frame and sub-assemblies of both the noise generator and the noise receiver have unit reference numbers in the sequence A0, A1, A2 etc. as follows :-

NOISE GENERATOR TF 2091C

A0	: Main frame	52091-930D
A1	: Noise source	44827-508S
A2	: Output amplifier	44827-509W
A3	: Output monitor	44827-510V
A4	: Attenuator	44827-511S
A5	: Attenuator	44827-512W
A6	: Interface board	44827-513D
AB0	: Power unit	44990-144V
AB1	: Power supply board	44827-514T
AC0	: Filter Unit (Automatic) TK 2087	52087-900N
AD0	: Filter Unit (Manual) TK 2087/1	52087-901L

NOISE RECEIVER TF 2092C

A0	: Main frame	52092-930Z
A1	: Standardizing noise source	44990-110F
A2	: 110 dB step attenuator	44827-271D
A3	: 9 dB step attenuator	44827-329J
A4	: Program board	54490-032H
A5	: Mixer board	44827-322Z
A6	: Display board	44827-323H
A7	: Control board	44828-100R
AB0	: Power unit	44990-117P
AB1	: Regulator board	44827-325U
AB2	: Rectifier board	44827-341D
AC0	: Filter Unit TK 2086	52086-900C
AC1	: Local oscillator mother board	44827-326Y
AC2	: Input filter switch	44827-327N
AC3	: Output filter switch	44827-328L

The complete reference of a part consists of the unit identification number followed by its circuit reference, e.g. TF 2092C A7C5 is capacitor C5 on the receiver control board. For convenience in the text and on the circuit diagrams the circuit reference is abbreviated by dropping this unit identification prefix. However when ordering spare parts or in any other correspondence the prefix must be quoted.

This chapter lists the components of each unit in alpha-numerical order of the complete circuit reference. The following abbreviations are used :-

C	:	capacitor
CO	:	changeover
Carb	:	carbon
Cer	:	ceramic
Cermet	:	resistance film on ceramic substrate
D	:	semiconductor diode
Elec	:	electrolytic
FB	:	ferrite bead
FS	:	fuse
JK	:	jack
L	:	inductor
LED	:	light emitting diode
Log	:	logarithmic law
M	:	meter
Met ox	:	metal oxide
MR	:	semiconductor diode
Mtg	:	mounting
OC	:	open collector
PL	:	plug
Plas	:	plastic
PLP	:	pilot lamp
ppm	:	parts per million
R	:	resistor and variable resistor
RV	:	variable resistor
S	:	switch
SK	:	socket
SPNO	:	single pole normally open
T	:	transformer
Tant	:	tantalum
TFC	:	thin film circuit
TH	:	thermistor
TP	:	terminal
TR	:	transistor
Var	:	variable or preset
VT	:	transistor
W	:	watts at 70 °C
W*	:	watts at 55 °C
WW	:	wire wound
X	:	ferrite bead
†	:	value selected during test; nominal value listed

Ordering

When ordering replacement parts, address the order to our Service Division (for address see rear cover) or nearest Agent. Specify the following information for each part required.

(1) Type* and serial number of instrument.

(2) Complete circuit reference.

(3) Description.

(4) Marconi Instruments code number.

* as given on the serial number label at the rear of the instrument; if this is superseded by a model number label, quote the model number instead of the type number.

If a part is not listed, state its function, location and description when ordering.

One or more of the parts fitted to the instrument may differ from those listed in this chapter for any of the following reasons.

(a) Components indicated by † have their value selected during test to achieve particular performance limits.

(b) Owing to supply difficulties components may be substituted by others of different type or value provided that the overall performance of the instrument is maintained.

(c) As part of a policy of continuous development, components may be changed in value or type to obtain detail improvements in performance.

Whenever there is such a difference between the component fitted and the one listed, always use a replacement the same type and value as found in the instrument.

Circuit reference	Description	M.I. code
NOISE GENERATOR		
A0: Main frame		
	When ordering, prefix circuit reference with A0.	
D1	LED lamp, red, with mount	28624-104W
D2	LED lamp, red, with mount	28624-104W
D3	LED lamp, red, with mount	28624-104W
D4	LED lamp, green, TIL211	28624-108X
D5	LED lamp, green, TIL211	28624-108X
D6	LED lamp, green, TIL211	28624-108X
D7	LED lamp, green, TIL211	28624-108X
D8	LED lamp, green, TIL211	28624-108X
D9	LED lamp, green, TIL211	28624-108X
D10	LED lamp, green, TIL211	28624-108X
D11	LED lamp, green, TIL211	28624-108X
D12	LED lamp, green, TIL211	28624-108X
ME1	100-0-100μA meter	44579-008E
PL1 to PL8	BNC 75Ω free plug	23443-330D
R1	Var cerm 1kΩ 10% 1W	25723-502N
	Knob for R1 (SET ZERO)	41149-017L
R2	Met film 3.9kΩ 2% ¼W	24773-287V
R3	Met film 120Ω 2% ¼W	24773-251L
R4	Met film 120Ω 2% ¼W	24773-251L
R5	Met film 120Ω 2% ¼W	24773-251L
R6	Met film 120Ω 2% ¼W	24773-251L
R7	Met film 120Ω 2% ¼W	24773-251L
R8	Met film 120Ω 2% ¼W	24773-251L
R9	Met film 120Ω 2% ¼W	24773-251L
R10	Met film 120Ω 2% ¼W	24773-251L
R11	Met film 120Ω 2% ¼W	24773-251L
R12	Met film 180Ω 2% ¼W	24773-255V
R13	Met film 1kΩ 2% ¼W	24773-273A

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
SA-SJ	FILTERS switch assembly (without push buttons)	44338-040M
	Push buttons for SA-SJ :-	
	black	23465-591N
	red (1 of 4)	23465-592L
	grey (1 of 3)	23465-595G
SL-SO	OUTPUT POWER switch assembly	44340-081D
SP	REMOTE switch (without push button)	44338-041C
	Push buttons (grey) for SP	23465-593J
SQ	NOISE ON/OFF switch	23462-262J
	SUPPLY switch and lamp - see list AB0	
SK1	BNC 75Ω bulkhead socket	23443-454L
SK2	BNC 50Ω bulkhead socket	23445-215U
SK3	BNC 50Ω bulkhead socket	23445-215U
SK4	BNC 75Ω bulkhead socket	23443-454L
SK5	BNC 75Ω bulkhead socket	23443-454L
SK6	BNC 75Ω bulkhead socket	23443-454L
SK7	BNC 75Ω bulkhead socket	23443-454L
SK8	BNC 75Ω bulkhead socket	23443-454L
SK9	BNC 50Ω bulkhead socket	23445-215U
SK10	BNC 50Ω bulkhead socket	23445-215U
SK11	8-way edge connector	23435-039H
SK12	8-way edge connector	23435-039H
SK13	8-way edge connector	23435-039H
SK14	8-way edge connector	23435-039H
SK15	32-way edge connector	23435-066R
SK16	12-way edge connector	23435-096M
SK17	24-way filter tray socket	23435-639W
SK18	36-way REMOTE socket	23435-453H

A1: Noise source

When ordering prefix circuit reference with A1.

Circuit reference	Description	M.I. code
	Complete board	44827-508S
C1	Plas 0.1μF 10% 100V	26582-211B
C2	Elec 100μF -20+100% 40V	26423-244C
C3	Plas 0.1μF 10% 100V	26582-211B
C4	Elec 100μF -20+100% 40V	26423-244C
C5	Elec 47μF -20+100% 40V	26423-232G
C6	Plas 0.1μF 10% 100V	26582-211B
C7	Plas 0.22μF 10% 100V	26582-226G
C8	Tant 2.2μF 20% 20V	26486-540K
C9	Plas 0.1μF 10% 100V	26582-211B
C10	Plas 0.1μF 10% 100V	26582-211B
C11	Elec 10μF -20+100% 63V	26423-215K
C12	Cer 0.022μF -25+50% 18V	26383-007R
C13	Cer 0.022μF -25+50% 18V	26383-007R
C14	Tant 2.2μF 20% 20V	26486-540K
C15	Var cer 10-40pF	26847-264V
C16 †	Plas 22pF ±2pF 350V	26516-090B
C17	Plas 0.47μF 10% 63V	26582-410P
C18	Plas 0.1μF 10% 100V	26582-211B
C19	Elec 10μF -20+100% 63V	26423-215K
C20	Cer 0.022μF -25+50% 18V	26383-007R
C21	Cer 0.022μF -25+50% 18V	26383-007R
C22	Tant 2.2μF 20% 20V	26486-540K
C23	Tant 2.2μF 20% 20V	26486-540K
C24	Cer 0.1μF -25+50% 30V	26383-031S
C25	Tant 2.2μF 20% 20V	26486-540K
C26	Plas 0.1μF 10% 100V	26582-211B
C27	Plas 0.1μF 10% 100V	26582-211B
C28	Tant 2.2μF 20% 20V	26486-540K
C29	Elec 47μF -20+100% 40V	26423-232G
C30	Plas 0.1μF 10% 100V	26582-211B
C31	Elec 4.7μF -20+100% 63V	26415-801M
C32	Cer 0.022μF -25+50% 18V	26383-007R
C33	Tant 1μF 20% 35V	26486-513U

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
D1	Z1M (red spot)	44521-019M
D2	1N4148	28336-676J
D3	1N4148	28336-676J
D4	1N4148	28336-676J
D5	1N4148	28336-676J
D6	1N4148	28336-676J
L1	1mH	23642-567C
IC1 to IC3	μA741C	28461-304T
R1	Met film 15kΩ 2% ¼W	24773-301P
R2	Met film 10kΩ 2% ¼W	24773-297M
R3	Met film 1kΩ 2% ¼W	24773-273A
R4 †	Met film 15kΩ 2% ¼W	24773-301P
R5	Var cermet 10kΩ 10% ½W	25711-543D
R6	Met film 180Ω 2% ¼W	24773-255V
R7	Met film 3kΩ 2% ¼W	24773-284J
R8	Met film 270Ω 2% ¼W	24773-259T
R9	Met film 2kΩ 2% ¼W	24773-280U
R10	Met film 1.3kΩ 2% ¼W	24773-276E
R11	Met film 1.3kΩ 2% ¼W	24773-276E
R12	Met film 620Ω 2% ¼W	24773-268B
R13	Met film 470Ω 2% ¼W	24773-265M
R14	Met film 470Ω 2% ¼W	24773-265M
R15	Met film 4.7kΩ 2% ¼W	24773-289W
R16	Var cermet 1kΩ 10% ½W	25711-544T
R17	Met film 130Ω 2% ¼W	24773-252J
R18	Met film 200Ω 2% ¼W	24773-256S
R19	Met film 2kΩ 2% ¼W	24773-280U
R20	Met film 270Ω 2% ¼W	24773-259T
R21	Met film 1kΩ 2% ¼W	24773-273A
R22	Met film 1.5kΩ 2% ¼W	24773-277U
R23	Met film 430Ω 2% ¼W	24773-264X
R24	Met film 470Ω 2% ¼W	24773-265M
R25	Met film 470Ω 2% ¼W	24773-265M
R26	Met film 4.7kΩ 2% ¼W	24773-289W
R27	Met film 62Ω 2% ¼W	24773-244E
R28	Met film 1.2kΩ 2% ¼W	24773-275H
R29	Met film 1kΩ 2% ¼W	24773-273A
R30	Met film 3kΩ 2% ¼W	24773-284J
R31	Met film 300Ω 2% ¼W	24773-260W
R32	Met film 47Ω 2% ¼W	24773-241A
R33	Met film 220Ω 2% ¼W	24773-257W
R34	Met film 1kΩ 2% ¼W	24773-273A
R35	Met film 68Ω 2% ¼W	24773-245U
R36	Met film 5.1kΩ 2% ¼W	24773-290V
R37	Met film 910Ω 2% ¼W	24773-272K
R38	Met film 220kΩ 2% ¼W	24773-329T
R39	Met film 4.7kΩ 2% ¼W	24773-289W
R40	Met film 10kΩ 2% ¼W	24773-297M
R41	Met film 10kΩ 2% ¼W	24773-297M
R42	Met film 15kΩ 2% ¼W	24773-301P
R43	Met film 620Ω 2% ¼W	24773-268B
R44	Met film 3kΩ 2% ¼W	24773-284J
R45	Carb 560kΩ 5% 1/8W	24311-939H
R46	Carb 470kΩ 5% 1/8W	24311-937A
R47	Met film 12kΩ 2% ¼W	24773-299R
R48	Met film 12kΩ 2% ¼W	24773-299R
R49	Met film 12kΩ 2% ¼W	24773-299R
R50	Met film 68Ω 2% ¼W	24773-245U
R51	Met film 33Ω 2% ¼W	24773-237K
R52	Met film 33Ω 2% ¼W	24773-237K
R53	Met film 33Ω 2% ¼W	24773-237K
R54	Met film 1kΩ 2% ¼W	24773-273A
R55	Met film 33Ω 2% ¼W	24773-237K
R56	Met film 3.6kΩ 2% ¼W	24773-286G
R57	Met film 3.6kΩ 2% ¼W	24773-286G

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
TR1	BC239C	28452-771P
TR2	BSX20	28452-197H
TR3	BSX20	28452-197H
TR4	2N4859A	28459-014T
TR5	BSX20	28452-197H
TR6	BSX20	28452-197H
TR7	BSX20	28452-197H
TR8	2N4859A	28459-014T
TR9	BSX20	28452-197H
TR10	BSX20	28452-197H
TR11	BSX20	28452-197H
TR12	BSX20	28452-197H
TR13	BSX20	28452-197H
TR14	BSX20	28452-197H

A2: Output amplifier

When ordering prefix circuit reference with A2.

	Complete board	44827-509W
C1	Tant 2.2μF 20% 20V	26486-540K
C2	Plas 0.1μF 10% 100V	26582-211B
C3	Tant 4.7μF 20% 10V	26486-554G
C4 †	Plas 39pF ±2pF 350V	26516-146W
C6	Var cer 7-35pF	26847-120U
C7	Tant 4.7μF 20% 35V	26486-556S
C8	Cer 0.01μF -20+80% 100V	26383-055L
C9	Elec 4.7μF -20+100% 63V	26415-801M
C10	Cer 0.01μF -20+80% 100V	26383-055L
C11	Tant 1μF 20% 35V	26486-513U
C12	Plas 0.22μF 10% 100V	26582-226G
C13	Plas 0.22μF 10% 100V	26582-226G
C14	Plas 0.1μF 10% 100V	26582-211B
C15	Plas 0.1μF 10% 100V	26582-211B
C16	Elec 47μF -20+100% 40V	26423-232G
C17	Plas 2.2μF 10% 63V	26582-418Z
C18	Elec 47μF -20+100% 40V	26423-232G
C19	Plas 0.1μF 10% 100V	26582-211B
C20	Cer 0.1μF -25+50% 30V	26383-031S
C21	Cer 10pF ±0.25pF 750V	26324-709S
C22	Plas 0.1μF 10% 100V	26582-211B
C23	Elec 47μF -20+100% 40V	26423-232G
C24	Cer 0.1μF -25+50% 30V	26383-031S
C25	Plas 0.1μF 10% 100V	26582-211B
C26	Plas 0.1μF 10% 100V	26582-211B
C27	Elec 47μF -20+100% 40V	26423-232G
C28	Cer 0.1μF -25+50% 30V	26383-031S
C29	Plas 100pF ±2pF 350V	26516-243J
C30	Cer 0.1μF -25+50% 30V	26383-031S
C31	Cer 0.1μF -25+50% 30V	26383-031S
D1	1N4148	28336-676J
D2	Z5B20	28372-786A
D3	Z5B11	28372-033K
L1	33μH	23642-558W
R1	Met film 91Ω 2% ¼W	24773-248L
R2	Met film 110Ω 2% ¼W	24773-250N
R3	Met film 2kΩ 2% ¼W	24773-280U
R4	Met film 330Ω 2% ¼W	24773-261D
R5	Met film 1.6kΩ 2% ¼W	24773-278Y
R6	Met film 470Ω 2% ¼W	24773-265M
R7	Met film 130Ω 2% ¼W	24773-252J
R8	Met film 100Ω 2% ¼W	24773-249J
R9	Met film 1.1kΩ 2% ¼W	24773-274Z
R10	Met film 820Ω 2% ¼W	24773-271B
R11	Met film 150Ω 2% ¼W	24773-253F
R12	Met film 1.1kΩ 2% ¼W	24773-274Z
R13	Met film 4.7kΩ 2% ¼W	24773-289W
R14	Met film 110Ω 2% ¼W	24773-250N
R15	Met film 1kΩ 2% ¼W	24773-273A
R16	Met film 1.8kΩ 2% ¼W	24773-279N

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R17	Met film 3kΩ 2% ¼W	24773-284J
R18	Met ox 2kΩ 2% ½W	24573-080X
R19	Met film 12kΩ 2% ¼W	24773-299R
R20	Met ox 2kΩ 2% ½W	24573-080X
R21	Met film 10kΩ 2% ¼W	24773-297M
R22	Met film 430Ω 2% ¼W	24773-264X
R23	Met film 6.2kΩ 2% ¼W	24773-292W
R24	Met film 12Ω 2% ¼W	24773-227T
R25	Met film 27Ω 2% ¼W	24773-235R
R26	Met film 12Ω 2% ¼W	24773-227T
R27	Met film 820Ω 2% ¼W	24773-271B
R28	Met film 180Ω 2% ¼W	24773-255V
R29	Met film 270Ω 2% ¼W	24773-259T
R30	Met film 110Ω 2% ¼W	24773-250N
R31	Met film 820Ω 2% ¼W	24773-271B
R32	Met film 33Ω 2% ¼W	24773-237K
TH1	130Ω 20%	25685-412V
TR1	BC239C	28452-771P
TR2	BFY90	28452-157R
TR3	BSX20	28452-197H
TR4	2N2905	28434-879X
TR5	BC237A	28455-421X
TR6	BC237A	28455-421X
TR7	2N2905	28434-879X
TR8	2N2219A	28454-804V
TR9	2N2219A	28454-804V
TR10	2N2905	28434-879X

A3: Output monitor

When ordering prefix circuit reference with A3.

	Complete board	44827-510V
C1	Plas 0.1μF 10% 100V	26582-211B
C2	Var cer 0.6 - 5pF	26845-151N
C3	Cer 2.2pF 5% 50V	26343-457R
C4	Plas 0.1μF 10% 100V	26582-211B
C5	Elec 22μF -20+100% 40V	26423-222E
C6	Plas 0.1μF 10% 100V	26582-211B
C8	Var cer 3.5 - 13pF	26847-112K
C9	Cer 0.022μF -25+50% 18V	26383-007R
C10	Cer 0.022μF -25+50% 18V	26383-007R
C11	Cer 0.022μF -25+50% 18V	26383-007R
C12	Cer 0.022μF -25+50% 18V	26383-007R
C13	Plas 0.1μF 10% 100V	26582-211B
C14	Plas 0.22μF 10% 100V	26582-226G
C15	Plas 0.1μF 10% 100V	26582-211B
C16	Plas 0.1μF 10% 100V	26582-211B
C17	Elec 22μF -20+100% 40V	26423-222E
C18	Plas 1μF 10% 100V	26582-217U
C19	Plas 1μF 10% 100V	26582-217U
C20	Plas 0.1μF 10% 100V	26582-211B
C21	Elec 4.7μF -20+50% 63V	26423-211M
C22	Elec 22μF -20+100% 40V	26423-222E
C23	Elec 22μF -20+100% 40V	26423-222E
C24	Var cer 10 - 40pF	26847-264V
C25	Plas 0.1μF 10% 100V	26582-211B
C26	Tant 2.2μF 20% 20V	26480-540K
C27	Cer 0.01μF -20+80% 100V	26383-055L
D1	1N4148	28336-678G
D2	1N4148	28336-678G
D3	1N4148	28336-678G
D4	1N4148	28336-678G
D5	1N4148	28336-678G
D6	1N4148	28336-678G
D7	BZY88C15	28372-303M
D8	BZY88C15	28372-303M
D9	1N4148	28336-678G
IC1	CA3039	28461-906Y
IC2	CA3039	28461-906Y
IC3	741EHC	28461-319U
IC4	741C	28461-304T

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R1	Met film 6.8kΩ 2% ¼W	24773-293D
R2	Met film 300Ω 2% ¼W	24773-260W
R3	Met film 7.5kΩ 2% ¼W	24773-294T
R4	Met film 5.6kΩ 2% ¼W	24773-291S
R5	Met film 1.2kΩ 2% ¼W	24773-275H
R6	Met film 100Ω 2% ¼W	24773-249J
R7	Met film 1.5kΩ 2% ¼W	24773-277U
R8	Met film 252Ω 0.25% ¼W	24732-316D
R9	Met film 1.284kΩ 0.25% ¼W	24732-319X
R10	Met film 214.3Ω 0.25% ¼W	24732-314S
R11	Met film 638Ω 0.25% ¼W	24732-318P
R12	Met film 216Ω 0.25% ¼W	24732-315W
R13	Met film 279Ω 0.25% ¼W	24732-317T
R14	Met film 7.5kΩ 2% ¼W	24773-294T
R15	Met film 6.8kΩ 2% ¼W	24773-293D
R16	Met film 1kΩ 2% ¼W	24773-273A
R17	Met film 20kΩ 1% ¼W	24761-821K
R18	Met film 20kΩ 1% ¼W	24761-821K
R19	Met film 1kΩ 0.1% ¼W	24723-306P
R20	Met film 1kΩ 0.1% ¼W	24723-306P
R21	Var cermet 4.7kΩ 10% ½W	25711-542W
R22	Met film 1kΩ 0.1% ¼W	24723-306P
R23	Met film 1kΩ 0.1% ¼W	24723-306P
R24	Met film 20kΩ 1% ¼W	24761-821K
R25	Met film 20kΩ 1% ¼W	24761-821K
R26	Met film 1.2kΩ 2% ¼W	24773-275H
R27	Var cermet 1kΩ 10% ½W	25711-544T
R28	Met film 3kΩ 2% ¼W	24773-284J
R29	Met film 3kΩ 2% ¼W	24773-284J
R30	Met film 300kΩ 2% ¼W	24773-332T
R31	Met film 300kΩ 2% ¼W	24773-332T
R32	Met film 4.7kΩ 2% ¼W	24773-289W
R33	Met film 5.1kΩ 2% ¼W	24773-290V
R34	Met film 6.8kΩ 2% ¼W	24773-293D
R35	Met film 200kΩ 2% ¼W	24773-328D
R36	Met film 200kΩ 2% ¼W	24773-328D
R37	Met film 6.8kΩ 2% ¼W	24773-293D
R38	Met film 200kΩ 2% ¼W	24773-328D
R39	Met film 91kΩ 2% ¼W	24773-320N
R40	Met film 6.8kΩ 2% ¼W	24773-293D
R41	Met film 200kΩ 2% ¼W	24773-328D
R42	Met film 91kΩ 2% ¼W	24773-320N
R43	Met film 200kΩ 2% ¼W	24773-328D
R44	Met film 100kΩ 2% ¼W	24773-321L
R45	Met film 5.6kΩ 2% ¼W	24773-291S
R46	Met film 4.7kΩ 2% ¼W	24773-289W
R47	Met film 1kΩ 2% ¼W	24773-273A
R48	Met film 2kΩ 2% ¼W	24773-280U
R49	Var cermet 1kΩ 10% ½W	25711-544T
R50	Met film 680Ω 2% ¼W	24773-269K
R51	Met film 560Ω 2% ¼W	24773-267R
R52	Met film 6.8kΩ 2% ¼W	24773-293D
R53	Met film 470Ω 2% ¼W	24773-265M
RLA-D	Relay	23486-501Z
TR1	BSX20	28452-197H
TR2	BC239	28452-771P
TR3	2N2219	28453-847F
TR4	BC237	28455-421X
TR5	BC239	28452-771P
TR6	BC239	28452-771P
TR7	BC239	28452-771P
TR8	BC239	28452-771P

A4: Attenuator

When ordering prefix circuit reference with A4.

	Complete board	44827-511S
C1	Plas 100pF ±2pF 350V	26516-243J
C2	Cer 0.1μF -25+50% 30V	26383-031S
C3	Cer 0.1μF -25+50% 30V	26383-031S
C4	Cer 0.1μF -25+50% 30V	26383-031S
C5	Cer 0.1μF -25+50% 30V	26383-031S
C6	Cer 0.1μF -25+50% 30V	26383-031S

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
C7	Cer 0.1μF -25+50% 30V	26383-031S
C8	Cer 0.1μF -25+50% 30V	26383-031S
C9	Cer 0.1μF -25+50% 30V	26383-031S
C10	Cer 0.1μF -25+50% 30V	26383-031S
C11	Cer 0.1μF -25+50% 30V	26383-031S
C12	Cer 0.1μF -25+50% 30V	26383-031S
C13	Cer 0.1μF -25+50% 30V	26383-031S
C14	Plas 120pF 2% 350V	26516-266H
IC1	7405A	28469-157K
L1	10μH	23642-555G
L2	10μH	23642-555G
L3	2.2μH	23642-551N
R1	Met film 61.36Ω 0.25% ¼W	24732-395A
R2	Met film 14.97Ω 0.25% ¼W	24732-392R
R3	Met film 61.36Ω 0.25% ¼W	24732-395A
R4	Met film 8.6Ω 0.5% ¼W	24753-693U
R5	Met film 322.7Ω 0.5% ¼W	24753-698F
R6	Met film 8.6Ω 0.5% ¼W	24753-693U
R7	Met film 8.6Ω 0.5% ¼W	24753-693U
R8	Met film 322.7Ω 0.5% ¼W	24753-698F
R9	Met film 8.6Ω 0.5% ¼W	24753-693U
R10	Met film 4.31Ω 0.5% ¼W	24753-692E
R11	Met film 650Ω 0.5% ¼W	24753-699G
R12	Met film 4.31Ω 0.5% ¼W	24753-692E
R13	Met film 750Ω 2% ¼W	24773-270R
RLA	Relay	23486-441J
RLB	Relay	23486-441J
RLC	Relay	23486-441J
RLD	Relay	23486-441J
RLE	Relay	23486-441J
RLF	Relay	23486-441J
RLG	Relay	23486-441J
RLH	Relay	23486-441J

Circuit reference	Description	M.I. code
X1	FX1242	23635-812H
X2	FX1242	23635-812H

A5: Attenuator (Generator)

When ordering prefix circuit reference with A5.

	Complete board	44827-512W
C1	Plas 100pF ±2pF 350V	26516-243J
C2	Cer 0.1μF -25+50% 30V	26383-031S
C3	Cer 0.1μF -25+50% 30V	26383-031S
C4	Cer 0.1μF -25+50% 30V	26383-031S
C5	Cer 0.1μF -25+50% 30V	26383-031S
C6	Cer 0.1μF -25+50% 30V	26383-031S
C7	Cer 0.1μF -25+50% 30V	26383-031S
C8	Cer 0.1μF -25+50% 30V	26383-031S
C9	Cer 0.1μF -25+50% 30V	26383-031S
C10	Cer 0.1μF -25+50% 30V	26383-031S
C11	Cer 0.1μF -25+50% 30V	26383-031S
C12	Cer 0.1μF -25+50% 30V	26383-031S
C13	Cer 0.1μF -25+50% 30V	26383-031S
C14	Plas 120pF 2% 350V	26516-266H
C15	Plas 33pF ±2pF 350V	26516-129H
L1	10μH	23642-555G
L2	10μH	23642-555G
L3	2.2μH	23642-551N
IC1	7405A	28469-157K
R1	Met film 61.36Ω 0.25% ¼W	24732-395A
R2	Met film 14.97Ω 0.25% ¼W	24732-392R
R3	Met film 61.36Ω 0.25% ¼W	24732-395A
R4	Met film 38.96Ω 0.25% ¼W	24732-393B
R5	Met film 52.65Ω 0.25% ¼W	24732-394K
R6	Met film 38.96Ω 0.25% ¼W	24732-393B
R7	Met film 16.97Ω 0.5% ¼W	24753-694Y
R8	Met film 157.2Ω 0.5% ¼W	24753-697J

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R9	Met film 16.97Ω 0.5% ¼W	24753-694Y
R10	Met film 21.01Ω 0.5% ¼W	24753-691H
R11	Met film 123.3Ω 0.5% ¼W	24753-690Z
R12	Met film 21.01Ω 0.5% ¼W	24753-691H
R13	Met film 750Ω 2% ¼W	24773-270R
RLA	Relay	23486-441J
RLB	Relay	23486-441J
RLC	Relay	23486-441J
RLD	Relay	23486-441J
RLE	Relay	23486-441J
RLF	Relay	23486-441J
RLG	Relay	23486-441J
RLH	Relay	23486-441J
X1	FX1242	23635-812H
X2	FX1242	23635-812H

A6: Interface board (Generator)

When ordering prefix circuit reference with A6.

	Complete board	44827-513D
IC1	7450	28466-451E
IC2	7450	28466-451E
IC3	7442	28465-003D
IC4	7405A	28469-157K
IC5	7409	28466-004H
IC6	7400	28466-321L
IC7	7409	28466-004H
IC8	7404	28469-156B
IC9	7450	28466-451E
IC10	7450	28466-451E
IC11	7450	28466-451E
IC12	7450	28466-451E
IC13	7450	28466-451E
IC14	7450	28466-451E
IC15	7486	28466-401D
IC16	7483	28469-360M
IC17	7402	28466-204B
IC18	7404	28469-156B
IC19	7420	28466-324G
IC20	7410	28466-323F
IC21	7402	28466-204B
IC22	7404	28469-156B
IC23	7400	28466-321L
IC24	7400	28466-321L
IC25	7402	28466-204B
IC26	7402	28466-204B
IC27	7400	28466-321L
IC28	7427	28466-205K
IC29	7404	28469-156B
IC30	7410	28466-323F
IC31	7402	28466-204B
IC32	7400	28466-321L
IC33	7404	28469-156B
IC34	7486	28466-401D
IC35	7402	28466-204B
IC36	7483	28469-360M
R1	Met film 680Ω 2% ¼W	24773-269K
R2	Met film 1kΩ 2% ¼W	24773-273A
R3	Met film 3.9kΩ 2% ¼W	24773-287V
R4	Met film 1kΩ 2% ¼W	24773-273A
R5	Met film 680Ω 2% ¼W	24773-269K
R6	Met film 3.9kΩ 2% ¼W	24773-287V
R7	Met film 1kΩ 2% ¼W	24773-273A
R8	Met film 680Ω 2% ¼W	24773-269K
R9	Met film 3.9kΩ 2% ¼W	24773-287V
R10	Met film 560Ω 2% ¼W	24773-267R
R11	Met film 1kΩ 2% ¼W	24773-273A
R12	Met film 1.2kΩ 2% ¼W	24773-275H
R13	Met film 1kΩ 2% ¼W	24773-273A
R14	Met film 680Ω 2% ¼W	24773-269K
R15	Met film 1.6kΩ 2% ¼W	24773-278Y
R16	Met film 1kΩ 2% ¼W	24773-273A

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R17	Met film 680Ω 2% ¼W	24773-269K
R18	Met film 1.6kΩ 2% ¼W	24773-278Y
R19	Met film 1kΩ 2% ¼W	24773-273A
R20	Met film 680Ω 2% ¼W	24773-269K
R21	Met film 1.6kΩ 2% ¼W	24773-278Y
R22	Met film 1kΩ 2% ¼W	24773-273A
R23	Met film 680Ω 2% ¼W	24773-269K
R24	Met film 1.6kΩ 2% ¼W	24773-278Y
R25	Met film 1kΩ 2% ¼W	24773-273A
R26	Met film 680Ω 2% ¼W	24773-269K
R27	Met film 1.6kΩ 2% ¼W	24773-278Y
R28	Met film 180Ω 2% ¼W	24773-255V
TR1	BC307	28435-227H
TR2	BC307	28435-227H
TR3	BC307	28435-227H
TR4	BC307	28435-227H
TR5	BC307	28435-227H
TR6	BC307	28435-227H
TR7	BCY70	28434-857Z
TR8	BC307	28435-227H
TR9	BC307	28435-227H
TR10	BC307	28435-227H
TR11	BC307	28435-227H
TR12	BC307	28435-227H
TR13	BC307	28435-227H
TR14	BC307	28435-227H
TR15	BC307	28435-227H
TR16	BC307	28435-227H
TR17	BC307	28435-227H
TR18	BC307	28435-227H

AB0: Power supply unit (Generator)

When ordering prefix circuit reference with AB0.

C1	Elec 2200μF -10+50% 25V	26426-085W
C2	Plas 0.1μF 10% 250V	26512-228Y

Circuit reference	Description	M.I. code
	Mains filter	23642-901F
FS1, FS2	Fuse link, 500mA (230V)	23411-056X
	Fuse link, 1A (115V)	23411-058C
	Fuse holder	23416-192R
	Cover for fuse holder	23416-198E
LP1	Neon lamp, including red lens	23733-154G
PL1	SUPPLY, 3-pin	23423-150L
SA	230V/115V switch	23467-161W
	Cover for SA	23423-999Y
	SUPPLY switch	23462-262J
	Cover for SUPPLY switch	37561-103D
T1	Mains transformer	43490-030T
TR1	MJ4000	28455-847N
TR2	2N3055	28456-567W

AB1: Power supply board (Generator)

When ordering prefix circuit reference with AB1.

	Complete board	44827-514T
C1	Elec 22μF -20+100% 63V	26415-806A
C2	Elec 100μF -20+100% 25V	26415-813U
C3	Cer 0.1μF -25+50% 30V	26383-031S
C4	Elec 470μF -20+100% 63V	26415-842Z
C5	Elec 220μF -20+100% 63V	26415-820J
C6	Elec 22μF -20+100% 63V	26415-806A
C7	Elec 22μF -20+100% 63V	26415-806A
C8	Plas 560pF 2% 500V	26516-430X
C9	Plas 560pF 2% 500V	26516-430X
C10	Plas 10μF -20+100% 63V	26415-802C
C11	Plas 1μF 10% 100V	26582-217U
C12	Elec 47μF -20+100% 63V	26415-811H
C13	Cer 0.1μF -25+50% 30V	26383-031S
C14	Cer 0.1μF -25+50% 30V	26383-031S
C15	Elec 47μF -20+100% 63V	26415-811H

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
D1	1N5401	28355-723N
D2	1N5401	28355-723N
D3	1N5401	28355-723N
D4	1N5401	28355-723N
D5	1N4004	28357-028K
D6	1N4004	28357-028K
D7	1N4004	28357-028K
D8	1N4004	28357-028K
D9	Z5B18	28372-583Z
D10	Z5B18	28372-583Z
D11	1N4148	28336-676J
D12	1N4148	28336-676J
D13	1N4148	28336-676J
D14	1N4148	28336-676J
D15	Z5B6.2	28371-483P
D16	1N4004	28357-028K
D17	1N4148	28336-676J
IC1	μA741C	28461-304T
IC2	μA723	28461-706F
IC3	μA723	28461-706F
R1	Met film 1.5kΩ 2% ¼W	24773-277U
R2	Var cermet 1kΩ 10% ½W	25711-544T
R3	Met film 4.3kΩ 2% ¼W	24773-288S
R4	Met film 1.2kΩ 2% ¼W	24773-275H
R5	Met film 4.7kΩ 2% ¼W	24773-289W
R6	Met film 4.7kΩ 2% ¼W	24773-289W
R7	WW 0.5Ω 10% 1½W	25133-031M
R8	Met film 1kΩ 2% ¼W	24773-273A
R9	Met ox 1.1kΩ 2% ½W	24573-074D
R10	Met film 1kΩ 2% ¼W	24773-273A
R11	Met film 3kΩ 2% ¼W	24773-284J
R12	Met film 3kΩ 2% ¼W	24773-284J
R13	Met ox 2.2kΩ 2% ½W	24573-081M
R14	Met film 13kΩ 2% ¼W	24773-300T
R15	Met film 1kΩ 2% ¼W	24773-273A
R16	Met ox 18Ω 2% ½W	24573-081M
R17	Met ox 1.8Ω 10% 3/8W	24582-559F
R18	Met film 5.6kΩ 2% ¼W	24773-291S
R19	Var cermet 220Ω 10% ½W	25711-546X
R20	Met film 1.8kΩ 2% ¼W	24773-279N
R21	Met film 10kΩ 2% ¼W	24773-297M
R22	Var cermet 220Ω 10% ½W	25711-546X
R23	Met film 1.6kΩ 2% ¼W	24773-278Y
R24	Met film 1kΩ 2% ¼W	24773-273A
TR1	BFY51	28455-827T
TR2	BC107	28455-437L
TR3	BC107	28455-437L
TR4	BCY71	28435-235L
TR5	MJE711	28435-870M

AC0: Filter Unit (Automatic) TK 2087 (Generator)

When ordering prefix circuit reference with AC0.

(1)	Complete unit	52087-900N
C1	Plas 2670pF 1% 160V	26516-940D
C2	Plas 0.01μF 10% 250V	26582-202T
C3	Plas 0.22μF 10% 100V	26582-226G
PL2	BNC 50Ω bulkhead plug	23445-145U
PL3	BNC 50Ω bulkhead plug	23445-145U
PL9	BNC 50Ω bulkhead plug	23445-145U
PL10	BNC 50Ω bulkhead plug	23445-145U
PL17	24-way plug	23435-609T
R1	Met film 20Ω 2% ¼W	24773-232X
R2	Met film 4.7Ω 2% ¼W	24773-217J
R3	Met film 5.6Ω 2% ¼W	24773-219G
R4	Met film 5.6Ω 2% ¼W	24773-219G
R5	Met film 10Ω 2% ¼W	24773-225W
(2)	Band limit assembly	44990-148T
C1	Cer 0.047μF -25+50% 12V	26383-016E
C2	Cer 0.047μF -25+50% 12V	26383-016E
C3	Cer 0.047μF -25+50% 12V	26383-016E

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
C4	Cer 0.047μF -25+50% 12V	26383-016E
C5	Cer 0.047μF -25+50% 12V	26383-016E
C6	Cer 0.047μF -25+50% 12V	26383-016E
C7	Cer 0.047μF -25+50% 12V	26383-016E
C8	Cer 0.047μF -25+50% 12V	26383-016E
PL11	BNC 75Ω plug	23443-330D
PL12	BNC 75Ω plug	23443-330D
PL13	BNC 75Ω plug	23443-330D
PL14	BNC 75Ω plug	23443-330D
RLA	Relay	23486-501Z
RLB	Relay	23486-501Z
RLC	Relay	23486-501Z
RLD	Relay	23486-501Z
RLE	Relay	23486-501Z
RLF	Relay	23486-501Z
RLG	Relay	23486-501Z
RLH	Relay	23486-501Z
RLI	Relay	23486-501Z
RLJ	Relay	23486-501Z
RLK	Relay	23486-501Z
RLL	Relay	23486-501Z
RLM	Relay	23486-501Z
SK11	BNC 75Ω bulkhead socket	23443-454L
SK12	BNC 75Ω bulkhead socket	23443-454L
SK13	BNC 75Ω bulkhead socket	23443-454L
SK14	BNC 75Ω bulkhead socket	23443-454L
(3)	Band stop assembly	44990-149P
C1	Cer 0.047μF -25+50% 12V	26383-016E
C2	Cer 0.047μF -25+50% 12V	26383-016E
C3	Cer 0.047μF -25+50% 12V	26383-016E
C4	Cer 0.047μF -25+50% 12V	26383-016E
C5	Cer 0.047μF -25+50% 12V	26383-016E
C6	Cer 0.047μF -25+50% 12V	26383-016E
C7	Cer 0.047μF -25+50% 12V	26383-016E
C8	Cer 0.047μF -25+50% 12V	26383-016E
C9	Cer 0.047μF -25+50% 12V	26383-016E
C10	Cer 0.047μF -25+50% 12V	26383-016E
C11	Cer 0.047μF -25+50% 12V	26383-016E
C12	Cer 0.047μF -25+50% 12V	26383-016E
PL1	BNC 75Ω free plug	23443-330D
PL2	BNC 50Ω bulkhead plug	23455-145U
PL3	BNC 50Ω bulkhead plug	23455-145U
PL4	BNC 75Ω free plug	23443-330D
PL5	BNC 75Ω free plug	23443-330D
PL6	BNC 75Ω free plug	23443-330D
PL7	BNC 75Ω free plug	23443-330D
PL8	BNC 75Ω free plug	23443-330D
RLA to RLZ	Relay	23486-501Z
SK1	BNC 75Ω bulkhead socket	23443-454L
SK4	BNC 75Ω bulkhead socket	23443-454L
SK5	BNC 75Ω bulkhead socket	23443-454L
SK6	BNC 75Ω bulkhead socket	23443-454L
SK7	BNC 75Ω bulkhead socket	23443-454L
SK8	BNC 75Ω bulkhead socket	23443-454L

AD0: Filter Unit (Manual) TK 2087/1

When ordering prefix circuit reference with AD0.

Complete unit	52087-901L
BNC 50Ω bulkhead plug (1 of 4)	23445-145U
Resistor, met film 36Ω	24773-238A
24-way plug	23435-609T

For symbols and abbreviations see introduction to this chapter.

NOISE RECEIVER

A0: Main frame

When ordering, prefix circuit reference with A0.

Circuit reference	Description	M.I. code
	Supply cable, side entry	43129-003W
C1	Cer 0.1μF +50-25% 30V	26383-031S
D1	LED lamp, red, with mount	28624-104W
D2	LED lamp, red, with mount	28624-104W
D3	LED lamp, red, with mount	28624-104W
D4	1N4148	28336-676J
D5	1N4148	28336-676J
JK1	Jack socket	23421-685E
M1	100-0-100μA meter	44579-009U
PL7	GP 90° free 50Ω	23444-057Y
	Ferrule for PL7	23231-804B
PL8	GP 90° free 50Ω	23444-057Y
	Ferrule for PL8	23231-803R
PL9	GP free 50Ω	23444-033G
	Ferrule for PL9	23231-803R
PL10	GP free 50Ω	23444-014R
	Ferrule for PL10	23231-805K
PL11	GP free 50Ω	23444-033G
	Ferrule for PL11	23231-803R
R1	Met film 360Ω 2% 1/4W	24773-262T
R2	Var cermet 100Ω 10% 1W	25723-503L
	Knob for R2	41149-017L
R3	Met film 180Ω 2% 1/4W	24773-255B
R4	Met film 470Ω 2% 1/4W	24773-265M
R5	Met film 1kΩ 2% 1/4W	24773-273A

Circuit reference	Description		M.I. code
SA	REMOTE CONTROL		44338-024J
SB	HOLD	Assy.	44338-021Y
SC	METER x2		
SD	INJECT 1pW/CHAN		
SE	ZERO		
SF	dB	Assy.	44338-022N
SG	1mW		
SH	1pW		
SJ	C-MESS		
SK	PSOPH		
Push-buttons :	dB		37590-103L
	1mW		37590-104J
	1pW		37590-105F
	PSOPH		37590-106G
	C-MESS		37590-114T
	For SA and SE		23465-593J
	For SB		23465-594F
	For SC and SD		23465-599D
SL, SM	Edge operated BCD output		23463-203A
SP	Supply ON		23462-252Z
	Cover for SP		37561-103D
SK1	BNC bulkhead mtg.		23445-215U
SK2	BNC bulkhead mtg.		23445-215U
SK3	24-way		23435-639W
SK4	BNC bulkhead mtg.		23445-215U
SK5	BNC jack. body pack		23443-380E
	BNC/TNC cable entry pack for SK5		23443-362D
	Ferrule for SK5		23231-804B
	Cable gland for SK2		33900-273S
	Cable gland for SK1 & 4		33900-272V
SK11	Edge connector, 8-way		23435-039H
SK12	Edge connector, 8-way		23435-039H
SK13	Edge connector, 32-way		23435-066R

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
SK14	Edge connector, 16-way	23435-052F
SK15	GP bulkhead mtg.	23444-193U
SK16	BNC receptacle 75Ω	23443-426V

A1: Standardizing noise source (Receiver)

When ordering, prefix circuit reference with A1.

	Complete board	44827-320K
C1	Cer 0.1μF -25+50% 30V	26383-031S
C2	Plas 0.22μF 10% 100V	26582-226G
C3	Plas 1μF 10% 100V	26582-217U
C4	Elec 220μF -20+100% 10V	26415-817K
C5 †	Plas 270pF 2% or 2pF 350V	26516-351V
C6	Elec 22μF -20+100% 25V	26415-805K
C7	Cer 0.1μF -25+50% 30V	26383-031S
C8	Plas 0.47μF 10% 63V	26582-410P
C9	Cer 0.1μF -25+50% 30V	26383-031S
C10	Cer 0.1μF -25+50% 30V	26383-031S
C11	Cer 0.1μF -25+50% 30V	26383-031S
D1	Noise diode Z1M	44521-025B
D2	1N4148	28336-676J
R1	Met film 2kΩ 2% ¼W	24773-280U
R2 †	Met film 27kΩ 2% ¼W	24773-307K
R3	Met film 6.8kΩ 2% ¼W	24773-293D
R4	Met film 75Ω 2% ¼W	24773-246Y
R5	Met film 6.8kΩ 2% ¼W	24773-293D
R6	Met film 100Ω 2% ¼W	24773-249J
R7 †	Met film 56Ω 2% ¼W	24773-243H
R8	Met film 150Ω 2% ¼W	24773-253F
R9	Met film 75Ω 2% ¼W	24773-246Y
R10	Met film 1kΩ 2% ¼W	24773-273A
R11	Met film 3.3kΩ 2% ¼W	24773-285F
R12	Var carb 47kΩ 20% ¼W	25611-082B
RLA	Relay 24V 2000Ω 2-pole c.o.	23486-126Y
RLB	Relay 24V 2000Ω 2-pole c.o.	23486-126Y

Circuit reference	Description	M.I. code
TR1	BC109C	28452-777K
TR2	BSX20	28452-197H
Double attenuator assembly :		44429-014X
SK7	GP receptacle	23444-193U
SK8	GP receptacle	23444-193U

A2: 110 dB step attenuator (Receiver)

When ordering, prefix circuit reference with A2.

	Complete board	44827-271D
C1	Plas 130pF 2% 160V	26516-276F
C2	Cer 0.1μF -25+50% 30V	26383-031S
C3	Cer 0.1μF -25+50% 30V	26383-031S
C4	Cer 0.1μF -25+50% 30V	26383-031S
C5	Plas 130pF 2% 160V	26516-276F
C6	Cer 0.1μF -25+50% 30V	26383-031S
C7	Cer 0.1μF -25+50% 30V	26383-031S
C8	Plas 130pF 2% 160V	26516-276F
C9	Cer 0.1μF -25+50% 30V	26383-031S
C10	Cer 0.1μF -25+50% 30V	26383-031S
C11	Cer 0.1μF -25+50% 30V	26383-031S
C12	Cer 0.1μF -25+50% 30V	26383-031S
C13	Cer 0.1μF -25+50% 30V	26383-031S
C14	Cer 0.1μF -25+50% 30V	26383-031S
C15	Cer 0.1μF -25+50% 30V	26383-031S
C16	Cer 0.1μF -25+50% 30V	26383-031S
C17	Cer 0.1μF -25+50% 30V	26383-031S
C18	Plas 33pF ±2pF 350V	26516-129H
IC1	Hex inverter, o.c. 7405A	28469-157K
L1	330μH	23642-331C
L2	10μH ±10%	23642-555G
L3	330μH	23642-564P
L4	330μH	23642-564P
L5	330μH	23642-564P
L6	330μH	23642-564P

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R1	Met film 61.36Ω 0.25% ¼W	24732-395A
R2	Met film 14.97Ω 0.25% ¼W	24732-392R
R3	Met film 122.7Ω 0.25% ¼W	24732-396Z
R4	Met film 14.97Ω 0.25% ¼W	24732-392
R5	Met film 61.36Ω 0.25% ¼W	24732-395
R6	Met film 61.36Ω 0.25% ¼W	24732-395
R7	Met film 14.97Ω 0.25% ¼W	24732-392
R8	Met film 61.36Ω 0.25% ¼W	24732-395
R9	Met film 38.96Ω 0.25% ¼W	24732-393B
R10	Met film 52.65Ω 0.25% ¼W	24732-394K
R11	Met film 38.96Ω 0.25% ¼W	24732-393B
R12	Met film 32.3Ω 0.5% ¼W	24753-695N
R13	Met film 70.9Ω 0.5% ¼W	24753-696L
R14	Met film 32.3Ω 0.5% ¼W	24753-695N
RLA	Reed 5V 500Ω	23486-441J
RLB	Reed 5V 500Ω	23486-441J
RLC	Reed 5V 500Ω	23486-441J
RLD	Reed 5V 500Ω	23486-441J
RLE	Reed 5V 500Ω	23486-441J
RLF	Reed 5V 500Ω	23486-441J
RLG	Reed 5V 500Ω	23486-441J
RLH	Reed 5V 500Ω	23486-441J
RLJ	Reed 5V 500Ω	23486-441J
X1	Ferrite bead FX1242	23635-812H
X2	Ferrite bead FX1242	23635-812H

A3: 9 dB step attenuator (Receiver)

When ordering, prefix circuit reference with A3.

	Complete board	44827-329J
C1	Plas 130pF 2% 160V	26516-276F
C2	Cer 0.1μF +50-25% 30V	26383-031S
C3	Cer 0.1μF +50-25% 30V	26383-031S
C4	Cer 0.1μF +50-25% 30V	26383-031S
C5	Plas 130pF 2% 160V	26516-276F
C6	Cer 0.1μF +50-25% 30V	26383-031S
C7	Cer 0.1μF +50-25% 30V	26383-031S
C9	Cer 0.1μF +50-25% 30V	26383-031S
C10	Cer 0.1μF +50-25% 30V	26383-031S
C11	Cer 0.1μF +50-25% 30V	26383-031S
C12	Cer 0.1μF +50-25% 30V	26383-031S
C13	Cer 0.1μF +50-25% 30V	26383-031S
C14	Cer 0.1μF +50-25% 30V	26383-031S
C15	Cer 0.1μF +50-25% 30V	26383-031S
C16	Cer 0.1μF +50-25% 30V	26383-031S
IC1	Hex inverter, o.c. 7405A	28469-157K
L1	330μH	23642-331C
L2	10μH 10%	23642-555G
L3	330μH	23642-564P
L4	330μH	23642-564P
L5	330μH	23642-564P
L6	330μH	23642-564P
R1	Met film 61.36Ω 0.25% ¼W	24732-395A
R2	Met film 14.97Ω 0.25% ¼W	24732-392R
R3	Met film 122.7Ω 0.25% ¼W	24732-396Z
R4	Met film 14.97Ω 0.25% ¼W	24732-392R
R5	Met film 61.36Ω 0.25% ¼W	24732-395A
R6	Met film 16.97Ω 0.5% ¼W	24753-694Y
R7	Met film 157.2Ω 0.5% ¼W	24753-697J
R8	Met film 16.97Ω 0.5% ¼W	24753-694Y
R9	Met film 8.6Ω 0.5% ¼W	24753-693U
R10	Met film 322.7Ω 0.5% ¼W	24753-698F
R11	Met film 8.6Ω 0.5% ¼W	24753-693U
R12	Met film 4.31Ω 0.5% ¼W	24753-692E
R13	Met film 650Ω 0.5% ¼W	24753-699G
R14	Met film 5.31Ω 0.5% ¼W	24753-692E
RLA	Reed 5V 500Ω	23486-441J
RLB	Reed 5V 500Ω	23486-441J
RLC	Reed 5V 500Ω	23486-441J
RLD	Reed 5V 500Ω	23486-441J

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
RLE	Reed 5V 500Ω	23486-441J
RLF	Reed 5V 500Ω	23486-441J
RLG	Reed 5V 500Ω	23486-441J
RLH	Reed 5V 500Ω	23486-441J
RLJ	Reed 5V 500Ω	23486-441J
X1	Ferrite bead FX1242	23635-812H
X2	Ferrite bead FX1242	23635-812H

A4 : Program board

When ordering, prefix circuit reference with A4.

	Board 44828-099U plus SK17, SK18 and 36-way free plug.	54490-032H
C2	Cer 0.01μF +80-20% 100V	26383-055L
C3	Cer 0.01μF +80-20% 100V	26383-055L
C4	Elec 4.7μF +100-20% 63V	26415-801M
C5	Cer 0.01μF +80-20% 100V	26383-055L
C6	Cer 0.022μF +50-25% 18V	26383-007R
D1	1N4148	28336-676J
D2	HG5004	28332-465G
D3	1N4148	28336-676J
IC1	7402	28466-204B
IC2	7474	28462-002N
IC3	SN74393	28464-122T
IC4	7437	28466-326S
IC5	7402	28466-204B
IC6	7445	28465-007M
IC7	7410	28466-323F
IC8	7475	28462-401R
IC9	μA741C	28461-304T
IC10	μA741C	28461-304T
IC11	7475	28462-401R
IC12	7475	28462-401R
IC13	7475	28462-401R
IC14	μA741C	28461-304T
R1	Met film 470Ω 2% ¼W	24773-265M
R2	Met film 43kΩ 2% ¼W	24773-312Z
R3	Met film 7.5kΩ 2% ¼W	24773-294T
R4	Met film 470Ω 2% ¼W	24773-265M
R5	Met film 43kΩ 2% ¼W	24773-312Z
R6	Met film 7.5kΩ 2% ¼W	24773-294T
R7	Met film 240Ω 2% ¼W	24773-258D
R8	Met film 43kΩ 2% ¼W	24773-312Z
R9	Met film 7.5kΩ 2% ¼W	24773-294T
R10	Met film 470Ω 2% ¼W	24773-265M
R11	Met film 43kΩ 2% ¼W	24773-312Z
R12	Met film 7.5kΩ 2% ¼W	24773-294T
R13	Met film 240Ω 2% ¼W	24773-258D
R14	Met film 43kΩ 2% ¼W	24773-312Z
R15	Met film 7.5kΩ 2% ¼W	24773-294T
R16	Met film 240Ω 2% ¼W	24773-258D
R17	Met film 7.5kΩ 2% ¼W	24773-294T
R18	Met film 43kΩ 2% ¼W	24773-312Z
R19	Met film 100kΩ 2% ¼W	24773-321L
R20	Met film 39kΩ 2% ¼W	24773-311A
R21	Met film 220kΩ 2% ¼W	24773-329T
R22	Met film 220kΩ 2% ¼W	24773-329T
R23 †	Met film 1.8kΩ 2% ¼W	24773-279N
R24	Met film 5.1kΩ 2% ¼W	24773-290V
R25	Met film 1.3kΩ 2% ¼W	24773-276E
R26	Met film 11kΩ 2% ¼W	24773-298C
R27 †	Met film 1.8kΩ 2% ¼W	24773-279N
R28	Met film 6.8kΩ 2% ¼W	24773-293D
R29	Met film 240Ω 2% ¼W	24773-258D
R30	Met film 15kΩ 2% ¼W	24773-301P
R31	Met film 150Ω 2% ¼W	24773-253F
R32	Met film 2kΩ 2% ¼W	24773-280U
R33	Met film 2kΩ 2% ¼W	24773-280U

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R34	Met film 4.7kΩ 2% ¼W	24773-289W
R35	Met film 15Ω 2% ¼W	24773-229X
R38	Met film 1.3kΩ 2% ¼W	24773-276E
R39	Met film 11kΩ 2% ¼W	24773-298C
R40	Met film 62kΩ 2% ¼W	24773-316Y
TR1	BC239C	28452-771P
TR2	BC239C	28452-771P
TR3	BC239C	28452-771P
TR4	BC239C	28452-771P
TR5	BC239C	28452-771P
TR6	BC239C	28452-771P
TR7	BC239C	28452-771P
TR8	BC239C	28452-771P

A5: Mixer board (Receiver)

When ordering, prefix circuit reference with A5.

	Complete board (excluding SK9 and 10)	44827-322Z
C1	Cer 0.022μF -25+50% 18V	26383-007R
C2	Cer 6.8pF ±0.25pF 750V	26324-706F
C3	Plas 0.47μF 10% 63V	26582-410P
C4	Plas 0.1μF 10% 100V	26582-211B
C5	Elec 22μF -20+100% 25V	26415-805K
C6	Cer 0.022μF -25+50% 18V	26383-007R
C7	Elec 4.7μF 20% 10V	26486-554G
C8	Plas 0.1μF 10% 100V	26582-211B
C9	Plas 150pF 2% 350V	26516-289C
C10	Var cer 10-60pF	26847-267D
C11	Plas 0.1μF 10% 100V	26582-211B
C12	Plas 0.47μF 10% 63V	26582-410P
C13	Elec 47μF -20+100% 10V	26415-809E
C14	Elec 470μF -20+100% 6.3V	26423-261L
C15	Cer 0.022μF -25+50% 18V	26383-007R
C16	Elec 47μF -20+100% 10V	26415-809E
C17	Cer 0.022μF -25+50% 18V	26383-007R
C18	Elec 22μF -20+100% 25V	26415-805K
C19	Cer 0.022μF -25+50% 18V	26383-007R
C20	Elec 22μF -20+100% 25V	26415-805K
C21	Elec 47μF -20+100% 10V	26415-809E
C22	Cer 0.022μF -25+50% 18V	26383-007R
C23	Plas 0.0523μF 1% 63V	26538-496M
C24	Plas 4050pF 1% 63V	26538-807X
C25	Plas 0.0378μF 1% 63V	26538-495X
C26	Plas 490pF 1% 63V	26538-623J
C27	Plas 1μF 10% 100V	26582-217U
C28	Plas 0.1μF 10% 100V	26582-211B
C29	Plas 0.1μF 10% 100V	26582-211B
C30	Plas 0.1μF 10% 100V	26582-211B
IC1	1496	28461-911L
IC2	μA741C	28461-304T
IC3	μA741C	28461-304T
L1	3.3mH	23642-343Y
R1	Met film 820Ω 2% ¼W	24773-271B
R2	Met film 10kΩ 2% ¼W	24773-297M
R3	Met film 3.6kΩ 2% ¼W	24773-286G
R4	Met film 120Ω 2% ¼W	24773-251L
R5	Met film 1.5kΩ 2% ¼W	24773-277U
R6	Met film 6.8kΩ 2% ¼W	24773-293D
R7	Met film 33kΩ 2% ¼W	24773-309Z
R8	Met film 1kΩ 2% ¼W	24773-273A
R9	Met film 910Ω 2% ¼W	24773-272K
R10	Met film 16kΩ 2% ¼W	24773-302X
R11	Met film 18kΩ 2% ¼W	24773-303M

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R12	Met film 200Ω 2% ¼W	24773-256S
R13	Met film 680Ω 2% ¼W	24773-269K
R14	Met film 62Ω 2% ¼W	24773-244E
R15	Met film 430Ω 2% ¼W	24773-264X
R16	Met film 75Ω 2% ¼W	24773-246Y
R17	Met film 100Ω 2% ¼W	24773-249J
R18	Met film 180Ω 2% ¼W	24773-255V
R19	Met film 910Ω 2% ¼W	24773-272K
R20	Met film 1.8kΩ 2% ¼W	24773-279N
R21	Met film 3kΩ 2% ¼W	24773-284J
R22	Met film 390Ω 2% ¼W	24773-263P
R23	Var cermet 470Ω 10% ½W	25711-541S
R24	Met film 2.7kΩ 2% ¼W	24773-283L
R25	Met film 200Ω 2% ¼W	24773-256S
R26	Met film 6.2kΩ 2% ¼W	24773-292W
R27	Met film 3.3kΩ 2% ¼W	24773-285F
R28	Met film 3.3kΩ 2% ¼W	24773-285F
R29	Met film 3kΩ 2% ¼W	24773-284J
R30	Met film 33kΩ 2% ¼W	24773-309Z
R31	Met film 11kΩ 2% ¼W	24773-298C
R32	Met film 10kΩ 2% ¼W	24773-297M
R33	Met film 110kΩ 2% ¼W	24773-322J
R34	Met film 4.7kΩ 2% ¼W	24773-289W
R35	Met film 220Ω 2% ¼W	24773-257W
SK9	GP bulkhead jack	23444-145X
SK10	GP bulkhead socket	23444-193U
	Ferrule for SK9	23231-803R
TR1	BC109	28452-789J
TR2	BFY90	28452-157R
TR3	BC109	28452-789J

A6: Display board

When ordering, prefix circuit reference with A6.

Complete assembly	44827-323H

Circuit reference	Description	M.I. code
IC1	MAN3630 LED display ±1	28624-207D
IC2	MAN 3620 } 7-segment LED numeric display	28624-206W
IC3	MAN 3620 } 7-segment LED numeric display	28624-206W
IC4	7447	28465-005P
IC5	7447	28465-005P
LP1	6V 0.36W wire leads	23735-291L
LP2	6V 0.36W wire leads	23735-291L
LP3	6V 0.36W wire leads	23735-291L
LP4	6V 0.36W wire leads	23735-291L
LP5	6V 0.36W wire leads	23735-291L
LP6	6V 0.36W wire leads	23735-291L
LP7	6V 0.36W wire leads	23735-291L
LP8	6V 0.36W wire leads	23735-291L
R1	Met film 150Ω 2% ¼W	24773-253F
R2	Met film 150Ω 2% ¼W	24773-253F
R3	Met film 150Ω 2% ¼W	24773-253F
R4	Met film 150Ω 2% ¼W	24773-253F
R5	Met film 150Ω 2% ¼W	24773-253F
R6	Met film 150Ω 2% ¼W	24773-253F
R7	Met film 150Ω 2% ¼W	24773-253F
R8	Met film 150Ω 2% ¼W	24773-253F
R9	Met film 150Ω 2% ¼W	24773-253F
R10	Met film 150Ω 2% ¼W	24773-253F
R11	Met film 150Ω 2% ¼W	24773-253F
R12	Met film 150Ω 2% ¼W	24773-253F
R13	Met film 150Ω 2% ¼W	24773-253F
R14	Met film 150Ω 2% ¼W	24773-253F
R15	Met film 150Ω 2% ¼W	24773-253F
R16	Met film 150Ω 2% ¼W	24773-253F
R17	Met film 150Ω 2% ¼W	24773-253F

A7: Control board

When ordering, prefix circuit reference with A7.

Complete assembly	44828-100K

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
C1	Plas 0.003μF 2% 125V	26516-597M
C2	Plas 100pF ±2pF 350V	26516-243J
C3	Elec 22μF -20+100% 25V	26415-805K
C4	Plas 0.1μF 10% 100V	26582-211B
C5	Cer 1.5pF ±0.25pF 750V	26324-008H
C6	Elec 100μF -20+100% 25V	26415-813U
C7	Elec 22μF -20+100% 25V	26415-805K
C10	Elec 10μF -20+100% 63V	26415-802C
C11	Elec 22μF -20+100% 25V	26415-805K
C12	Elec 22μF -20+100% 25V	26415-805K
C13	Elec 470μF -20+100% 10V	26415-821F
C14	Elec 470μF -20+100% 10V	26415-821F
C15	Cer 0.01μF -20+80% 100V	26383-055L
C16	Cer 0.01μF -20+80% 100V	26383-055L
C17	Cer 0.01μF -20+80% 100V	26383-055L
C18	Elec 47μF -20+100% 10V	26415-809E
C19	Elec 47μF -20+100% 10V	26415-809E
C20	Cer 0.01μF -20+80% 100V	26383-055L
C21	Plas 0.47μF 10% 63V	26582-410P
C22	Cer 0.001μF -20+80% 500V	26383-242P
C23	Cer 0.001μF -20+80% 500V	26383-242P
C24	Cer 0.001μF -20+80% 500V	26383-242P
C25	Cer 0.001μF -20+80% 500V	26383-242P
C26	Cer 0.001μF -20+80% 500V	26383-242P
C27	Cer 0.001μF -20+80% 500V	26383-242P
C28	Cer 0.001μF -20+80% 500V	26383-242P
C29	Cer 0.001μF -20+80% 500V	26383-242P
C30	Cer 0.001μF -20+80% 500V	26383-242P
C31	Cer 0.001μF -20+80% 100V	26383-055L
C32	Cer 0.001μF -20+80% 100V	26383-055L
C33	Cer 0.01μF -20+80% 100V	26383-055L
C34	Cer 0.01μF -20+80% 100V	26383-055L
C35	Cer 0.01μF -20+80% 100V	26383-055L
C36	Cer 0.01μF -20+80% 100V	26383-055L
C37	Cer 0.01μF -20+80% 100V	26383-055L
C38	Cer 0.001μF -20+80% 500V	26383-242P

Circuit reference	Description	M.I. code
C39	Cer 0.001μF -20+80% 500V	26383-242P
C40	Cer 0.01μF -20+80% 100V	26383-055L
C41	Cer 0.01μF -20+80% 100V	26383-055L
C42	Cer 0.001μF -20+80% 500V	26383-242P
C43	Cer 0.001μF -20+80% 500V	26383-242P
C44	Plas 0.22μF 10% 63V	26582-406T
D1	1N4148	28336-676J
D2	1N4148	28336-676J
D3	1N4148	28336-676J
D4	1N4148	28336-676J
D5	1N4148	28336-676J
D6	1N4148	28336-676J
D7	1N4148	28336-676J
D9	1N4148	28336-676J
D10	1N4148	28336-676J
D11	1N4148	28336-676J
D12	1N4148	28336-676J
D13	1N4148	28336-676J
D14	1N4148	28336-676J
D15	1N4148	28336-676J
D16	1N4148	28336-676J
D17	1N4148	28336-676J
D18	1N4148	28336-676J
IC1	μA741C	28461-304T
IC2	μA748	28461-310M
IC3	μA741C	28461-304T
IC4	SN76502P	28461-315A
IC5	μA741C	28461-304T
IC6	μA741C	28461-304T
IC8	μA 741C	28461-304T
IC9	μA741C	28461-304T
IC10	μA741C	28461-304T
IC11	N5556V	28461-311C
IC12	SN72514P	28461-698L
IC13	SN72514P	28461-698L

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
IC14	7474	28462-002N
IC15	7474	28462-002N
IC16	7474	28462-002N
IC17	7474	28462-002N
IC18	7410	28466-323F
IC19	7475	28462-401R
IC20	7404	28469-156B
IC21	7475	28462-401R
IC22	7475	28462-401R
IC23	7402	28466-204B
IC24	7425	28466-208H
IC25	7400	28466-321L
IC26	7400	28466-321L
IC27	7483	28469-360M
IC28	7483	28469-360M
IC29	7486	28466-401D
IC30	7400	28466-321L
IC31	7400	28466-321L
IC32	7400	28466-321L
IC33	7420	28466-324G
IC34	7400	28466-321L
IC35	7400	28466-321L
IC36	7474	28462-002N
IC37	7402	28466-204B
IC38	7410	28466-323F
IC39	74192	28464-105U
IC40	7425	28466-208H
IC41	7404	28469-156B
IC42	7475	28462-401R
IC43	7410	28466-323F
IC44	7486	28466-401D
IC45	7486	28466-401D
IC46	7483	28469-360M
IC47	7483	28469-360M
IC48	7483	28469-360M
IC49	7475	28462-401R
IC50	74193	28464-106Y
IC51	7425	28466-208H
IC52	7404	28469-156B
IC53	7402	28466-204B
IC54	7402	28466-204B
IC55	7410	28466-323F
IC56	7474	28462-002N
IC57	μA748	28461-310M
IC58	7404	28469-156B
IC59	7400	28466-321L
IC60	7404	28469-156B
IC61	7400	28466-321L
IC62	7425	28466-208H
IC63	7483	28469-360M
IC64	7483	28469-360M
IC65	7402	28466-204B
IC66	7483	28469-360M
R1	Met film 16kΩ 2% ¼W	24773-302X
R2	Carb var 47kΩ 20% ¼W	25611-082B
R3	Met film 180kΩ 2% ¼W	24773-327W
R4	Met film 15kΩ 2% ¼W	24773-301P
R5	Met film 220kΩ 2% ¼W	24773-329T
R6	Met film 2.7kΩ 2% ¼W	24773-283L
R7	Met film 10kΩ 2% ¼W	24773-297M
R8	Met film 1kΩ 2% ¼W	24773-273A
R9	Met film 1kΩ 2% ¼W	24773-273A
R10	Met film 1.6kΩ 2% ¼W	24773-278Y
R11	Met film 20kΩ 2% ¼W	24773-304C
R12	Met film 15kΩ 2% ¼W	24773-301P
R13	Met film 15kΩ 2% ¼W	24773-301P
R14	Met film 20kΩ 2% ¼W	24773-304C
R15	Met film 7.5kΩ 2% ¼W	24773-294T
R16	Met film 6.2kΩ 2% ¼W	24773-292W
R17	Met film 82kΩ 2% 1/4W	24773-319J
R19	Met film 100Ω 2% ¼W	24773-249J
R20	Met film 10kΩ 2% ¼W	24773-297M

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R21	Carb 2.7MΩ 10% 1/8W	24321-878F
R22	Carb 2.7MΩ 10% 1/8W	24321-878F
R23	Met film 100kΩ 2% ¼W	24773-321L
R24	Met film 62kΩ 2% ¼W	24773-316Y
R25	Met film 5.1kΩ 2% ¼W	24773-290V
R26	Met film 20kΩ 2% ¼W	24773-304C
R27	Met film 160kΩ 2% ¼W	24773-326S
R28	Met film 160kΩ 2% ¼W	24773-326S
R29	Met film 5.6kΩ 2% ¼W	24773-291S
R30	Met film 3.9kΩ 2% ¼W	24773-287V
R31	Met film 5.3kΩ 1% ¼W	24761-851R
R32	Met film 6.0kΩ 0.25% ¼W	24732-306L
R33	Met film 16kΩ 2% ¼W	24773-302X
R34	Met film 51kΩ 2% ¼W	24773-314E
R35	Met film 33kΩ 2% ¼W	24773-309Z
R36	Met film 200Ω 2% ¼W	24773-256S
R37	Met film 4.7kΩ 2% ¼W	24773-289W
R38	Met film 2kΩ 2% ¼W	24773-380U
R39	Met film 2.7kΩ 2% ¼W	24773-283L
R40	Met film 200Ω 2% ¼W	24773-256S
R41	Met film 4.7kΩ 2% ¼W	24773-289W
R42	Met film 390Ω 2% ¼W	24773-263P
R43 †	Met film 68Ω 2% ¼W	24773-245U
R44	Met film 4.7kΩ 2% ¼W	24773-289W
R45	Met film 360Ω 2% ¼W	24773-262T
R46 †	Met film 68Ω 2% ¼W	24773-245U
R47	Met film 68Ω 2% ¼W	24773-245U
R48	Met film 1kΩ 2% ¼W	24773-273A
R49	Met film 1kΩ 2% ¼W	24773-273A
R50	Met film 1kΩ 2% ¼W	24773-273A
R51	Met film 68kΩ 2% ¼W	24773-317N
R52	Met film 1kΩ 2% ¼W	24773-273A
R53	Met film 12kΩ 2% ¼W	24773-299R
R54	Met film 620Ω 2% ¼W	24773-268B
R55	Met film 1kΩ 2% ¼W	24773-273A
R56	Met film 160kΩ 2% ¼W	24773-326S
R57	Met film 160kΩ 2% ¼W	24773-326S
R58	Met film 1kΩ 2% ¼W	24773-273A
R59	Met film 2kΩ 2% ¼W	24773-280U
R60	Met film 1kΩ 2% ¼W	24773-273A
R61	Met film 2kΩ 2% ¼W	24773-280U
R62	Var cermet 220kΩ 10% ¼W	25711-509T
R63	Met film 100Ω 2% ¼W	24773-249J
R64	Met film 100Ω 2% ¼W	24773-249J
RLA	5V 500Ω SPNO	23486-442F
RLB	5V 500Ω SPNO	23486-442F
RLC	5V 500Ω SPNO	23486-442F
RLD	12V 330Ω 4-pole c.o.	23486-131L
RLE	5V 500Ω SPNO	23486-442F
RLF	5V 500Ω SPNO	23486-442F
TR1	BSX20	28452-197H
TR2	BSX20	28452-197H
TR3	BSX20	28452-197H
TR4	BSX20	28452-197H
TR5	BSX20	28452-197H

AB0: Power supply unit (Receiver)

When ordering, prefix circuit reference with AB0.

	Complete unit	44990-117P
C1	Elec 4700μF +50-10% 25V	26426-092X
C2	Elec 1000μF +50-10% 63V	26426-081F
FS1, FS2	Fuse link, 500mA (230V)	23411-056X
	Fuse link, 1A (115V)	23411-058C
	Fuse holder	23416-192R
	Cover for fuse holder	23416-198E
PL1	SUPPLY 3-pin	23423-150L
SA	2-pole c.o.	23467-161W
SCR1	BTY 79/100R	28385-707K
	Mounting kit for SCR1	28488-142H

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
T1	Transformer assembly	43490-020J
TR1	RCA1000	28455-847N
TR2	2N3055	28456-567W
	Insulating washer for TR1	28488-128X
	Insulating bush for TR2	28488-119V
	Insulating washer for TR2	28488-120F
	Cover for TR1 and TR2	28488-202M
	Mains filter	23642-901F

AB1: Regulator board

When ordering, prefix circuit reference with AB1.

	Complete board	44827-325A
C1	Elec 220μF +100-20% 10V	26415-817J
C2	Elec 100μF +100-20% 40V	26415-814Y
C3	Elec 4.7μF +100-20% 63V	26415-801M
C4	Cer 0.047μF +50-25% 30V	26383-018Y
C5	Plas 500pF 2% 350V	26516-414L
C6	Cer 0.047μF +50-25% 30V	26383-018Y
C7	Elec 4.7μF +100-20% 63V	26415-801M
C8	Plas 500pF 2% 350V	26516-414L
C9	Cer 0.047μF +50-25% 30V	26383-018Y
C10	Cer 0.047μF +50-25% 30V	26383-018Y
C11	Cer 0.047μF +50-25% 30V	26383-018Y
C12	Plas 0.0022μF 5% 350V	26516-566C
C13	Cer 0.047μF +50-25% 30V	26383-018Y
C14	Elec 100μF +100-20% 25V	26415-813U
C15	Elec 22μF +50-20% 100V	26415-807Z
C16	Elec 100μF +100-20% 25V	26415-813U
D1	Zener 18V 5% 0.4W	28372-583Z
D2	Zener 18V 5% 0.4W	28372-583Z
D3	1N4148	28336-676J
D4	Zener 10V 5% 0.4W	27361-843E
D5	Zener 12V 5% 0.4W	28372-143U
D6	Zener 12V 5% 0.4W	28372-143U
D7	Zener 5.6V 5% 0.4W	28371-434Y
D8	Zener 3V 5% 0.4W	28371-203G
D9	1N4148	28336-676J
D10	1N4148	28336-676J
IC1	μA723C	28461-701U
IC2	μA723C	28461-701U
IC3	μA741C	28461-304T
IC4	μA723C	28461-701U
R1	WW 2.7kΩ 5% 1½W	25123-092D
R2	Met film 680Ω 2% ¼W	24773-269K
R3	Met film 1.5kΩ 2% ¼W	24773-277U
R4	Met film 2.2kΩ 2% ¼W	24773-281Y
R5	Met film 5.6kΩ 2% ¼W	24773-291S
R6	Met ox 1.8Ω 10% 3/8W	24582-559F
R7	Met film 6.2kΩ 2% ¼W	24773-292W
R8	Met film 1.2kΩ 2% ¼W	24773-275H
R9	Met film 8.2kΩ 2% ¼W	24773-295P
R10	WW 150Ω 5% 3W	25125-054J
R11	Met film 7.5kΩ 2% ¼W	24773-294T
R12	Met film 1.5kΩ 2% ¼W	24773-277U
R13	Met film 1.6kΩ 2% ¼W	24773-278Y
R14	Met film 2.2kΩ 2% ¼W	24773-281Y
R15	Met film 6.8kΩ 2% ¼W	24773-293D
R16	Met film 5.1kΩ 2% ¼W	24773-290V
R17	Met film 10kΩ 2% ¼W	24773-297M
R18	Met film 2.2kΩ 2% ¼W	24773-281Y
R19	Met ox 22Ω 2% ½W	24573-033J
R20	Met film 10kΩ 2% ¼W	24773-297M
R21	Met ox 18Ω 2% ½W	24573-031N
R22	Met film 2.7kΩ 2% ¼W	24773-283L
R23	Met film 750Ω 2% ¼W	24773-270R
R24	WW 0.5Ω 10% 1½W	25133-031M
R25	Met film 2.7kΩ 2% ¼W	24773-283L
R26	Met film 10Ω 2% ¼W	24773-225W

For symbols and abbreviations see Introduction to this chapter

Circuit reference	Description	M.I. code
R27	Met film 180Ω 2% ¼W	24773-255V
R28	Met film 1.2kΩ 2% ¼W	24773-275H
R29	Met film 2.2kΩ 2% ¼W	24773-282N
R30	Met film 1.2kΩ 2% ¼W	24773-275H
R31	Met film 2.7kΩ 2% ¼W	24773-283L
R32	Met film 680Ω 2% ¼W	24773-269K
R33	Met film 270Ω 2% ¼W	24773-259T
R341	Carb 470kΩ 5% 1/8W	24311-937A
R35	Var cermet 220Ω 10% ½W	25711-546X
R36	Var cermet 1kΩ 10% ½W	25711-544T
R37	Var cermet 1kΩ 10% ½W	25711-544T
TR1	BFX85	28455-837K
TR2	BC107B	28455-437L
TR3	BC107B	28455-437L
TR4	BFX85	28455-837K
TR6	BFY51	28455-827T
TR7	BCY71	28435-235L
TR8	2N2905A	28434-879X
TR9	BFY51	28455-827T
TR11	BCY71	28435-235L

AB2: Rectifier board

When ordering, prefix circuit reference with AB2.

	Complete board	44827-341D
C3	Elec 1000μF +100-20% 25V	26415-826D
C4	Elec 1000μF +100-20% 25V	26415-826D
C5	Elec 100μF +50-20% 100V	26415-816L
C6	Plas 0.68μF 10% 100V	26582-216E
C7	Plas 0.68μF 10% 100V	26582-216E
C8	Plas 0.68μF 10% 100V	26582-216E
D1 to D4	Bridge Int. Rect. 5SB05	28359-171K
D5	1N4004	28357-028K
D6	1N4004	28357-028K
D7	1N4004	28357-028K
D8	1N4004	28357-028K
D9	1N4004	28357-028K
D10	1N4004	28357-028K
D11	1N4004	28357-028K
FS1	5A link 20mm x 5mm	23411-009J

AC0: Filter Unit TK 2086

When ordering, prefix circuit reference with AC0.

LP1	28V 24mA flying leads	23735-482R
LP2	28V 24mA flying leads	23735-482R
LP3	28V 24mA flying leads	23735-482R
LP4	28V 24mA flying leads	23735-482R
LP5	28V 24mA flying leads	23735-482R
LP6	28V 24mA flying leads	23735-482R
PL1	GP 50Ω bulkhead	23445-145U
PL2	GP 50Ω bulkhead	23445-145U
PL3	24-way fixed	23435-609T
PL4	GP 50Ω bulkhead	23445-145U
	Cable gland for PL1	33900-273S
	Cable gland for PL4	33900-272V
R1-R6	Var carb 470Ω 20% 0.06W	25531-349S

AC1: Local oscillator mother board

When ordering, prefix circuit reference with AC1.

	Complete board	44827-326Y
C1	Plas 0.1μF 10% 100V	26582-211B
C2	Elec 4.7μF 20% 35V	26486-556S
C3	Plas 0.1μF 10% 100V	26582-211B
D1	1N4148	28336-676J
D2	1N4148	28336-676J
D3	1N4148	28336-676J
D4	1N4148	28336-676J

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
D5	1N4148	28336-676J
D6	1N4148	28336-676J
R1	Met film 1.8kΩ 2% ¼W	24773-279N
R2	Met film 150Ω 2% ¼W	24773-253F
RLA	4-pole c.o. 24V 850Ω	23486-153A
RLB	4-pole c.o. 24V 850Ω	23486-153A
RLC	4-pole c.o. 24V 850Ω	23486-153A
RLD	4-pole c.o. 24V 850Ω	23486-153A
RLE	4-pole c.o. 24V 850Ω	23486-153A
RLF	4-pole c.o. 24V 850Ω	23486-153A
SA to SF	Channel select	44338-023L
	Push-button for SA-SF	23465-595G
SK1	Edge connector 4-way	43169-006R
SK2	Edge connector 4-way	43169-006R
SK3	Edge connector 4-way	43169-006R
SK4	Edge connector 4-way	43169-006R
SK5	Edge connector 4-way	43169-006R
SK6	Edge connector 4-way	43169-006R
SK7	Edge connector 8-way	23435-038Z
SK8	Edge connector 8-way	23435-038Z

AC2: Input filter switch (Receiver)

When ordering, prefix circuit reference with AC2.

	Complete assembly	44827-327N
C1	Cer 0.01μF +80-20% 100V	26383-055L
C2	Cer 0.01μF +80-20% 100V	26383-055L
C3	Cer 0.01μF +80-20% 100V	26383-055L
C4	Cer 0.01μF +80-20% 100V	26383-055L
C5	Cer 0.01μF +80-20% 100V	26383-055L
C6	Cer 0.01μF +80-20% 100V	26383-055L

Circuit reference	Description	M.I. code
PL17 to PL19	Each plug consists of the following :	
PL20	BNC free body pack	23443-374F
PL21	BNC/TNC cable entry pack	23443-370C
PL22		
RLA	Reed 24V 3000Ω SPNO	23486-443G
RLB	Reed 24V 3000Ω SPNO	23486-443G
RLC	Reed 24V 3000Ω SPNO	23486-443G
RLD	Reed 24V 3000Ω SPNO	23486-443G
RLE	Reed 24V 3000Ω SPNO	23486-443G
RLF	Reed 24V 3000Ω SPNO	23486-443G

AC3: Output filter switch (Receiver)

When ordering, prefix circuit reference with AC3.

	Complete assembly	44827-328L
C1	Cer 0.01μF +80-20% 100V	26383-055L
C2	Cer 0.01μF +80-20% 100V	26383-055L
C3	Cer 0.01μF +80-20% 100V	26383-055L
C4	Cer 0.01μF +80-20% 100V	26383-055L
C5	Cer 0.01μF +80-20% 100V	26383-055L
C6	Cer 0.01μF +80-20% 100V	26383-055L
PL11	BNC free 76Ω	23443-331T
PL12	BNC free 76Ω	23443-331T
PL13	BNC free 76Ω	23443-331T
PL14	BNC free 76Ω	23443-331T
PL15	BNC free 76Ω	23443-331T
PL16	BNC free 76Ω	23443-331T
RLA	Reed 24V 3000Ω SPNO	23486-443G
RLB	Reed 24V 3000Ω SPNO	23486-443G
RLC	Reed 24V 3000Ω SPNO	23486-443G
RLD	Reed 24V 3000Ω SPNO	23486-443G
RLE	Reed 24V 3000Ω SPNO	23486-443G
RLF	Reed 24V 3000Ω SPNO	23486-443G

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
Oscillator junction box		44990-113S
R1	Met film 680Ω 2% 1/8W	24773-269K

Meter damping board

When ordering, prefix circuit reference with Meter Damping.

	Complete assembly	44828-424V
C1	Elec 100μF 100-20% 10V	26423-240T
C2	Elec 100μF 100-20% 10V	26423-240T
R1	Met film 15kΩ 2% ¼W	24773-301P
R2	Met film 39kΩ 2% ¼W	24773-311A

MISCELLANEOUS MECHANICAL PARTS

Top cover	35900-952H
Bottom cover	35900-953E
Front handle (1 of 2)	35852-118D
Side handle (1 of 2)	35852-114G
Rear stand plate (1 of 2)	35900-971T
Bottom stand	35116-109M
Front foot (1 of 2)	37588-111K
Casting for mounting side handle (1 of 2)	35838-128G
Rear foot (1 of 2)	22315-604E
Front trim, above filter tray	
Retaining screw for filter unit (1 of 2)	33900-350P

For symbols and abbreviations see introduction to this chapter

Chapter 7

Circuit diagrams

Circuit notes

1. COMPONENT VALUES

Resistors : No suffix = ohms, k = kilohms, M = megohms.
Capacitors : No suffix = microfarads, p = picofarads.
† value selected during test; nominal value shown.

2. VOLTAGES

These are d.c. and relative to chassis unless otherwise indicated. Measured with 20 kΩ/V meter.

3. SYMBOLS

arrow indicates clockwise rotation of knob.

etc., external front or rear panel marking.

tag on printed board.

other tag.

feed-through tag.

screwdriver adjustable preset.

signal path.

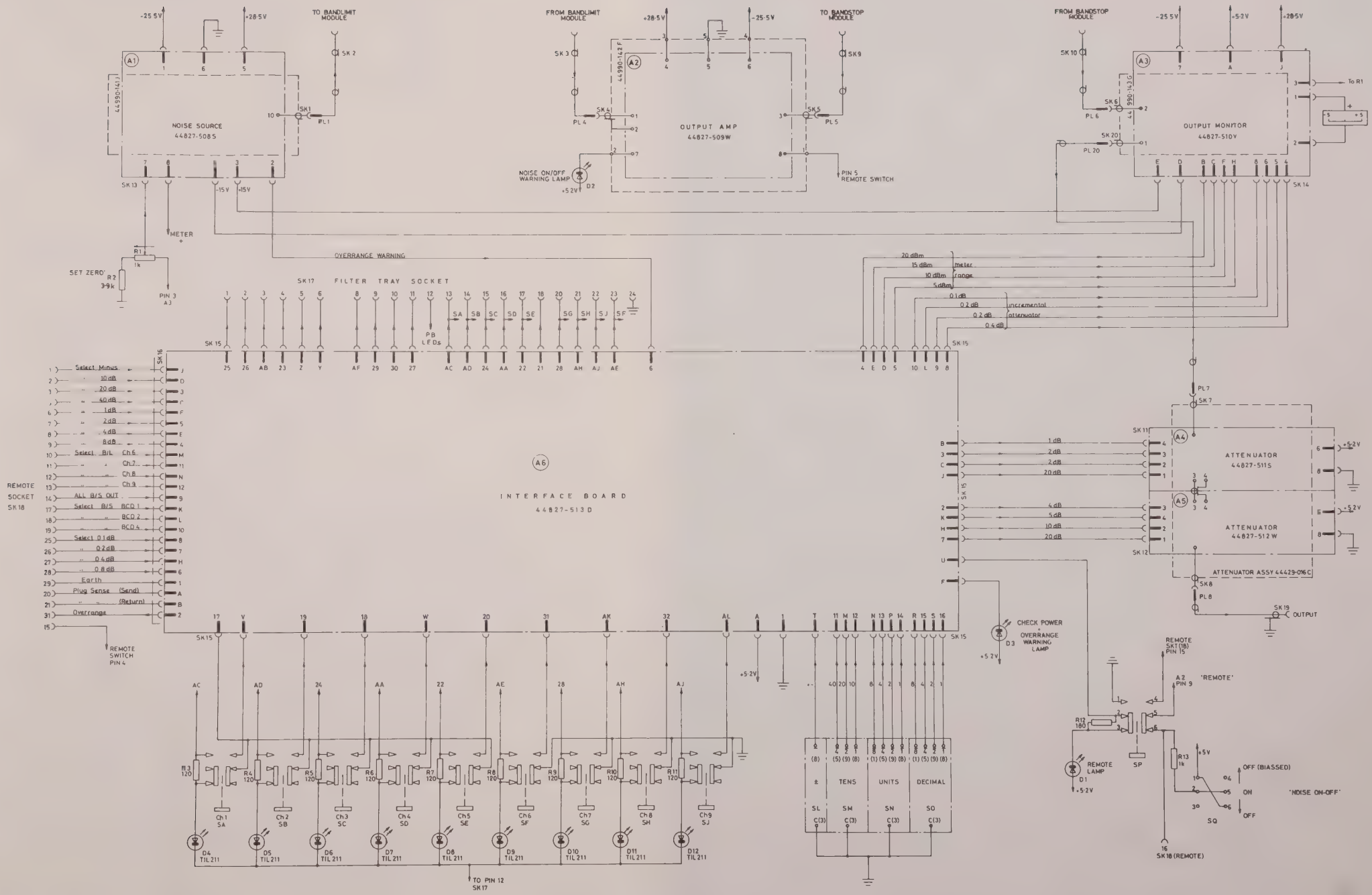
feedback path.

4. SWITCHES

Rotary switches are drawn schematically. Numbers or letters indicate control knob setting.

1F = 1st section (front panel), front
1B = 1st section, back
2F = 2nd section, front
etc.

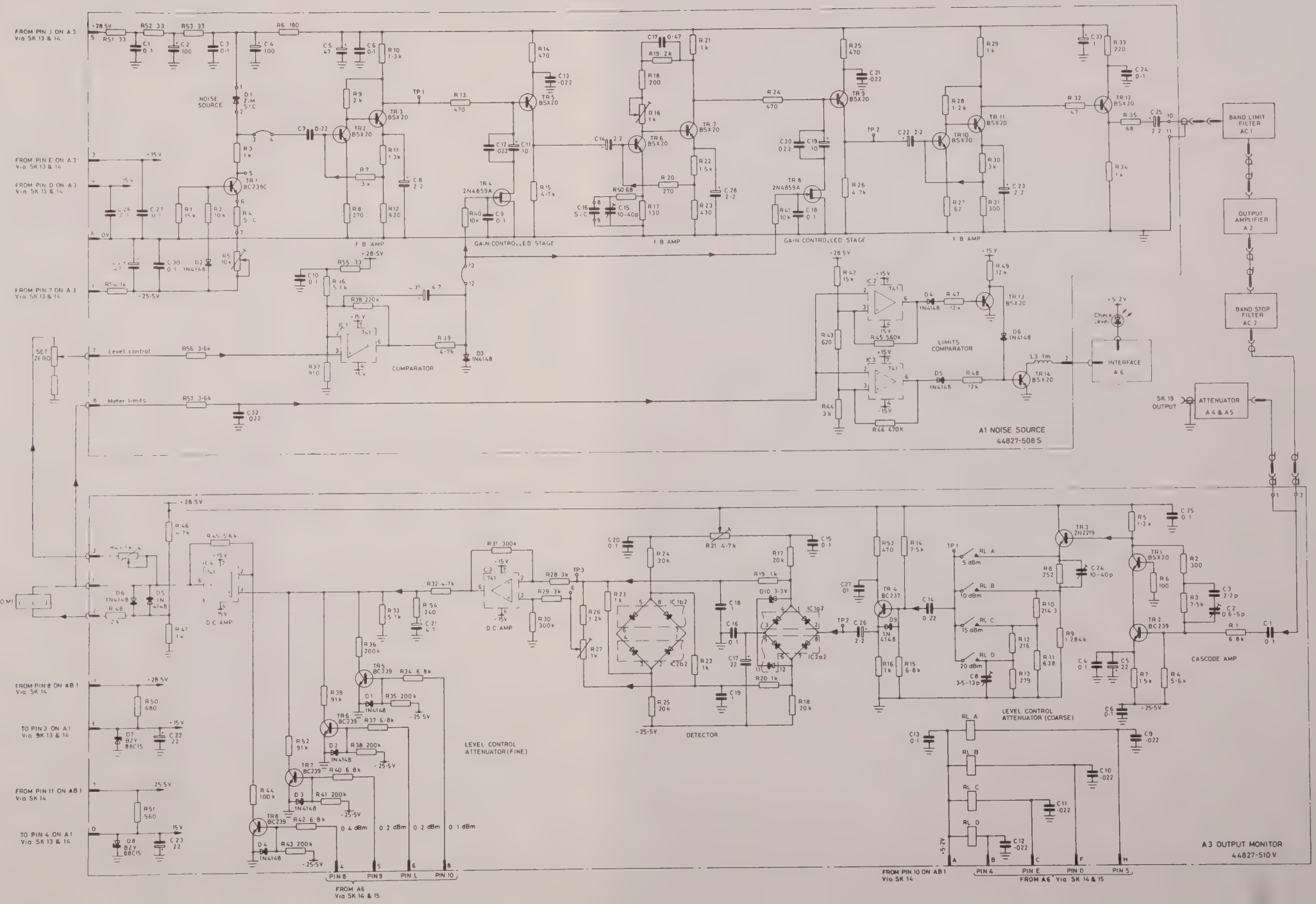
Switches are shown in the non-operated position or, where all positions are operative, the switch is shown in the first or initialized position.



DRG. No. Z52091-930D SHT. 1 OF 3 ISS. 6

Generator main frame wiring: AO

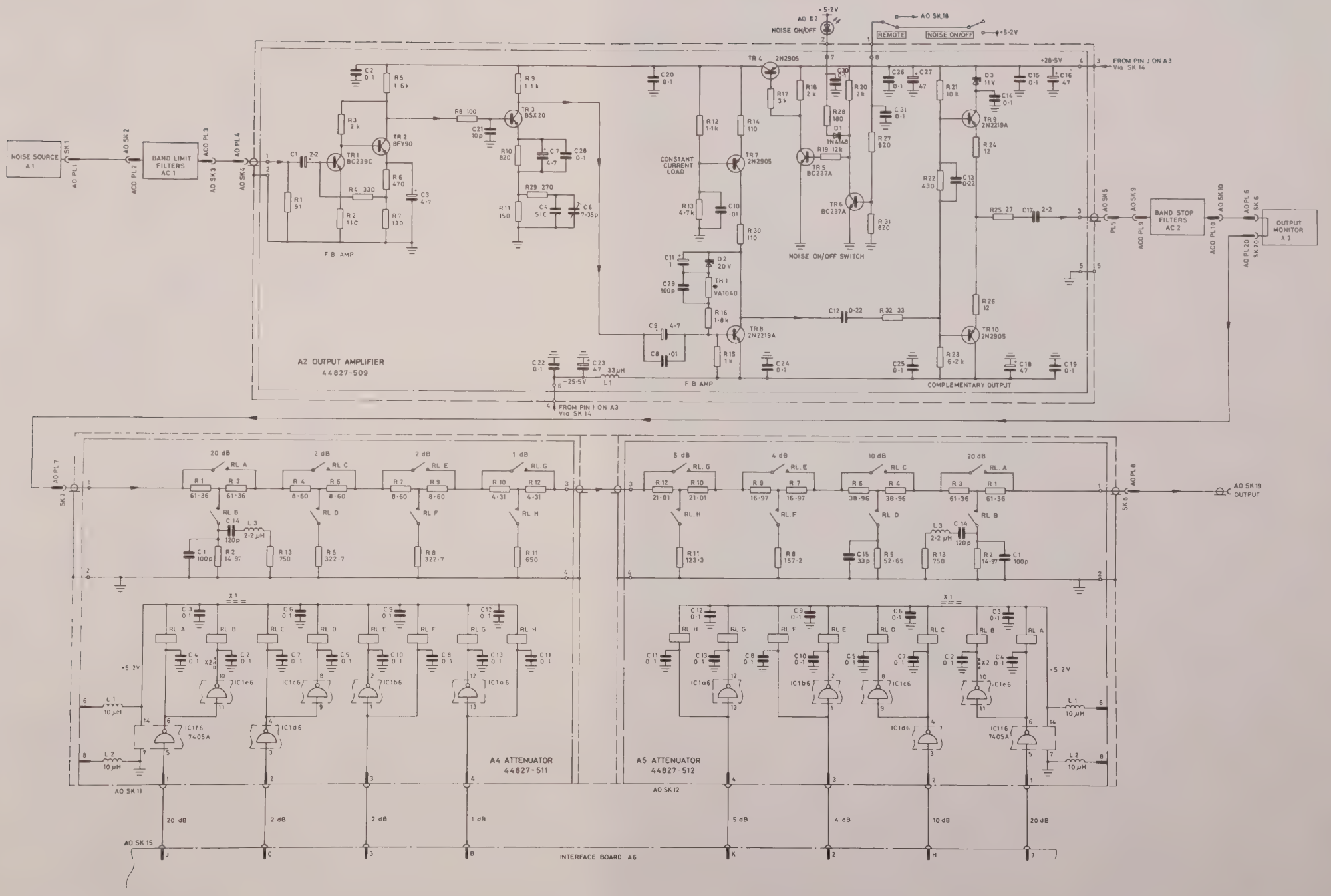
Fig. 7.1



ORG.No.Z52091-930 D SHT. 2 OF 3 ISS.6

Noise source: A1
Output monitor: A3

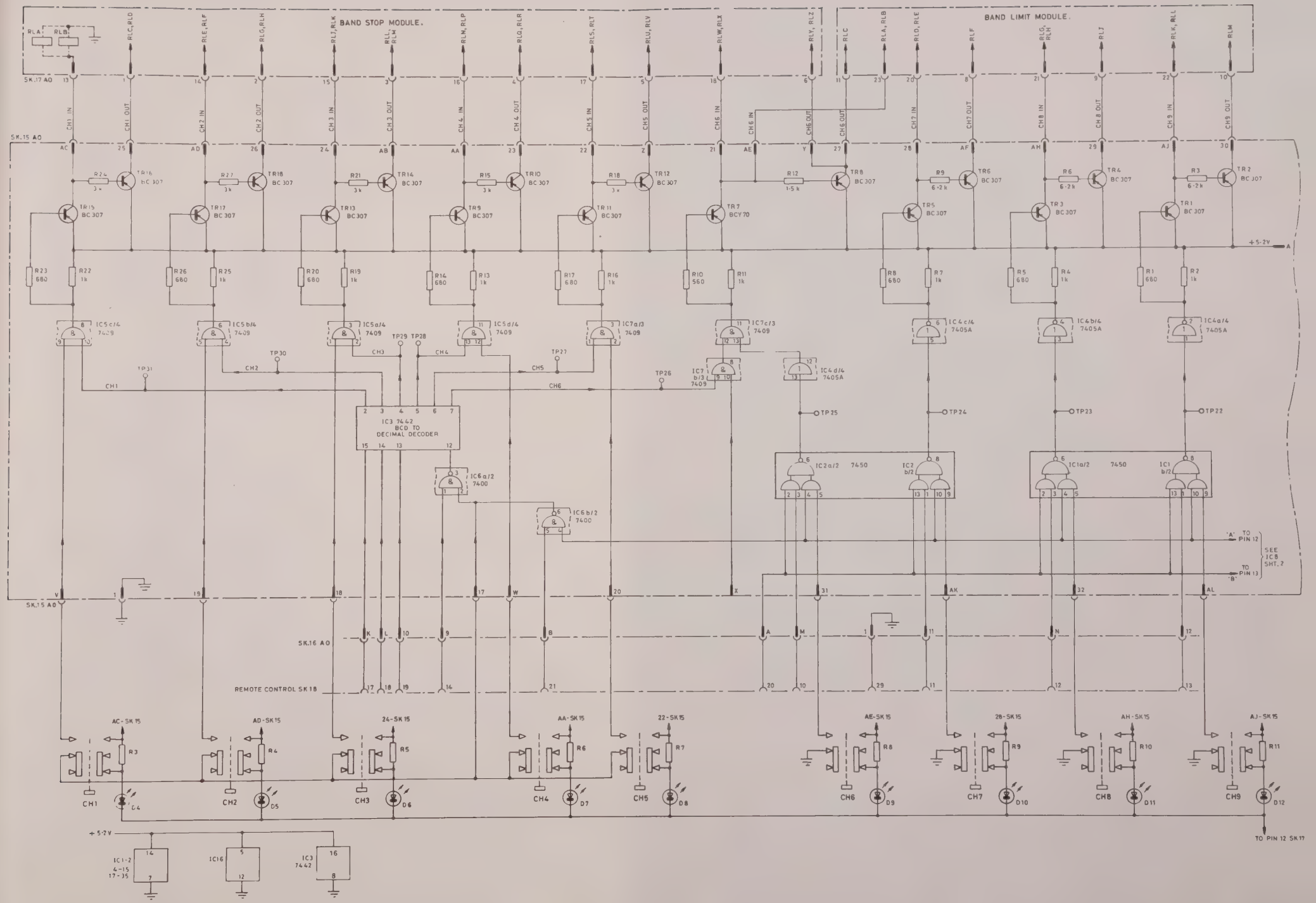
Fig.7.2



DRG.No. Z52091-930D SHEET 3 OF 3 ISS. 6

Output amplifier: A2 Attenuators: A4 and A5

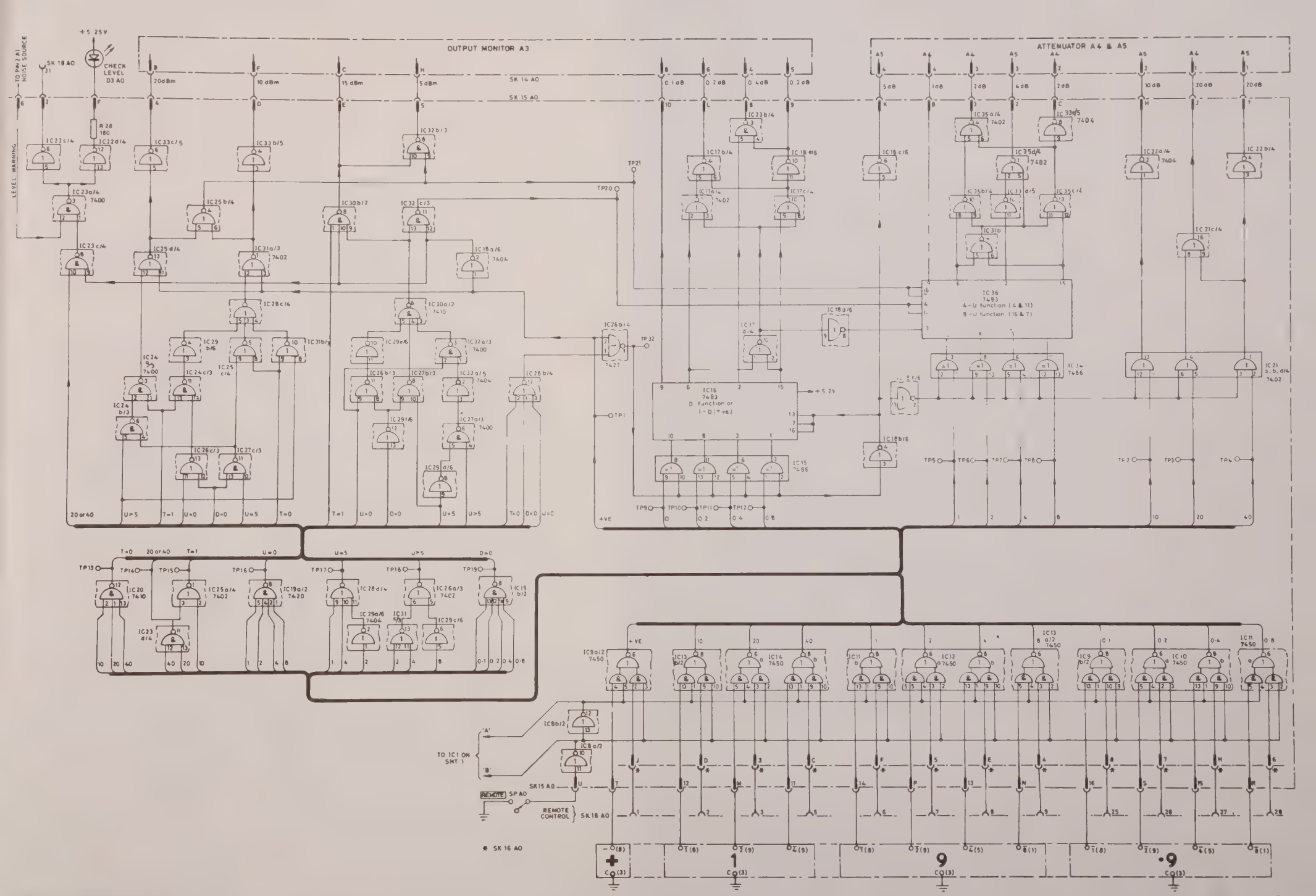
Fig.7.3



DRG. No. Z44827-513D SHT 1 OF 2 ISS. 7

Interface board: A6 (filter switching)

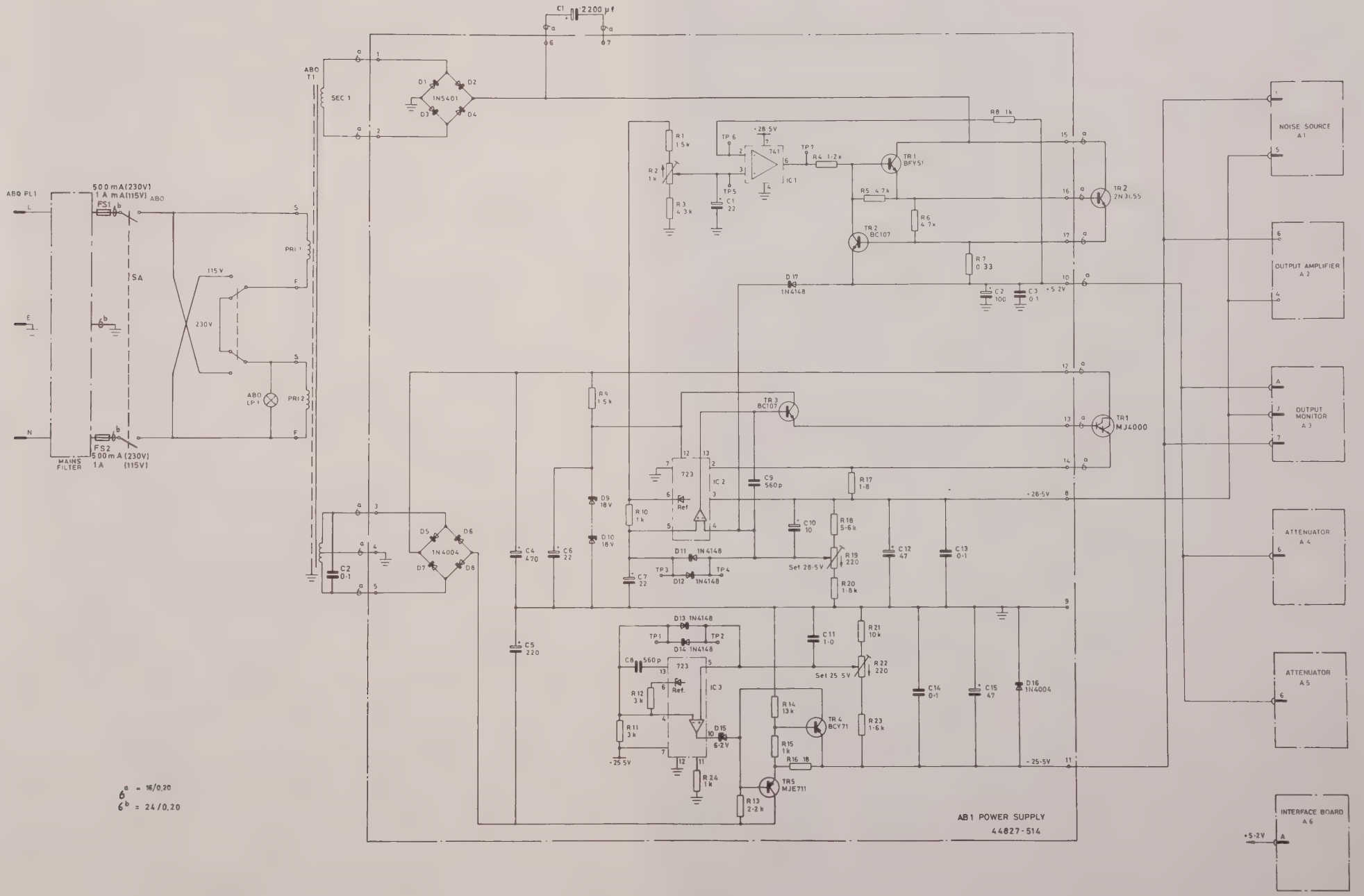
Fig. 7.4



DRG.No. Z44827-513D SHT 2 OF 2 ISS.7

Interface board: A6 (output level control)

Fig. 7.5

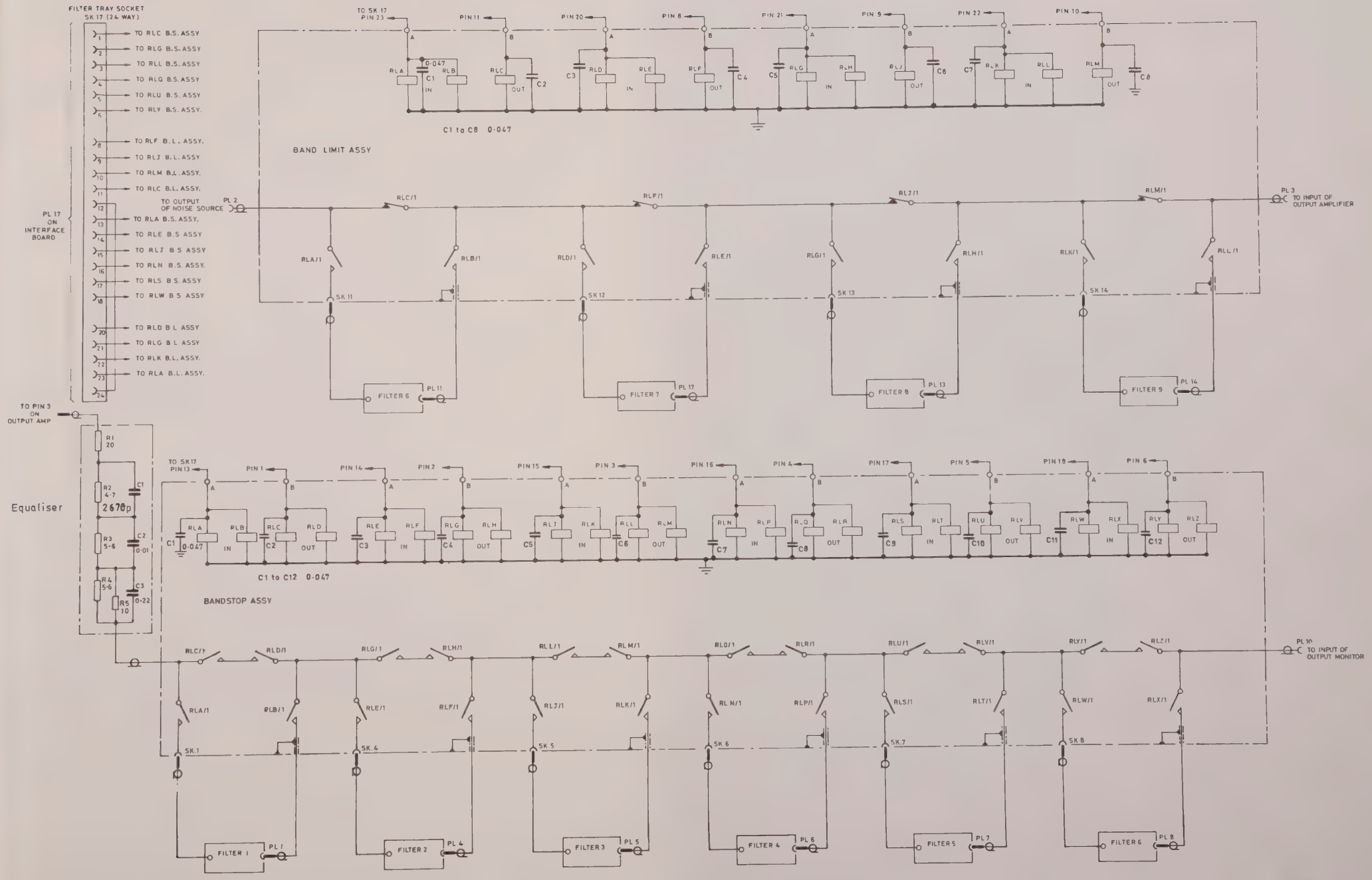


DRG.No. Z44990-144V ISS. 9

Power supply: AB0 and AB1

Fig. 7.6
Generator

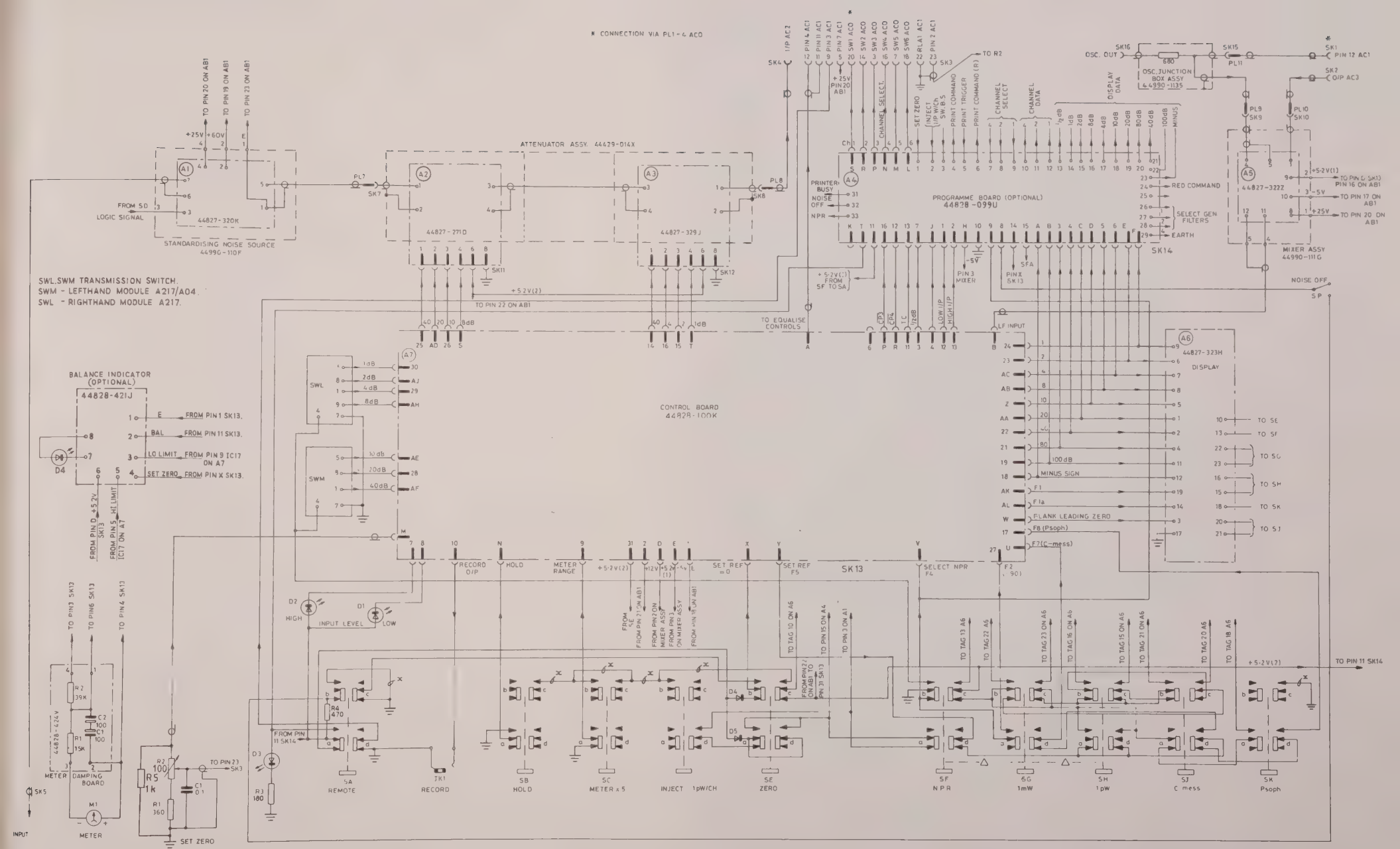
2090-930 (2a)



DRG. No. Z52087-900N ISS. 5

Filter Unit (Automatic) TK2087
Noise Generator

Fig. 7.7
Generator

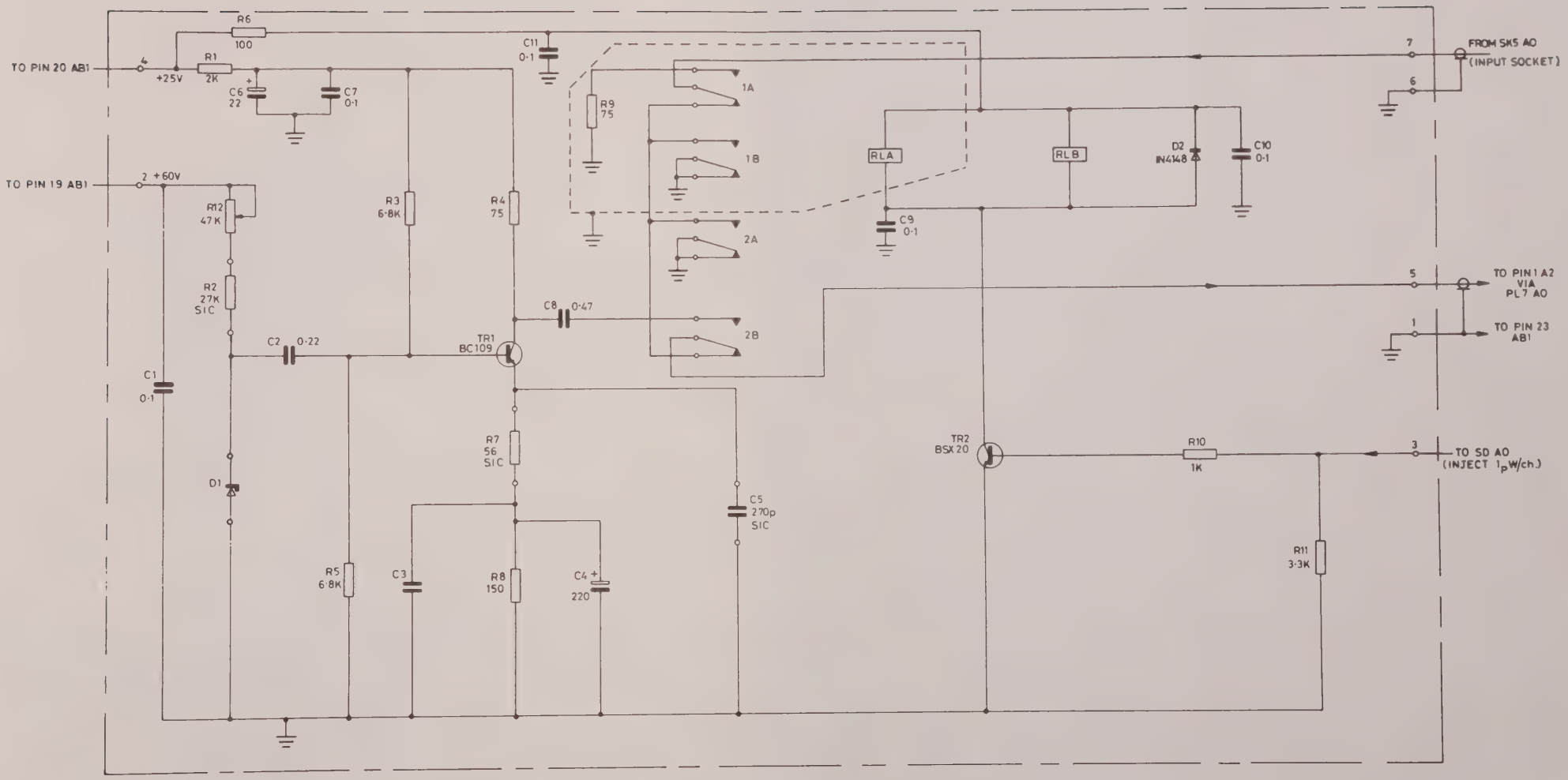


NOTE:- LEADS MARKED ~~6~~ X ARE FOR MECHANICAL STABILITY OF SWITCH ASSEMBLY ONLY.

DRG. No. Z52092-930Z ISS. 10

Receiver main frame wiring: AO

Fig. 7.8
Receiver

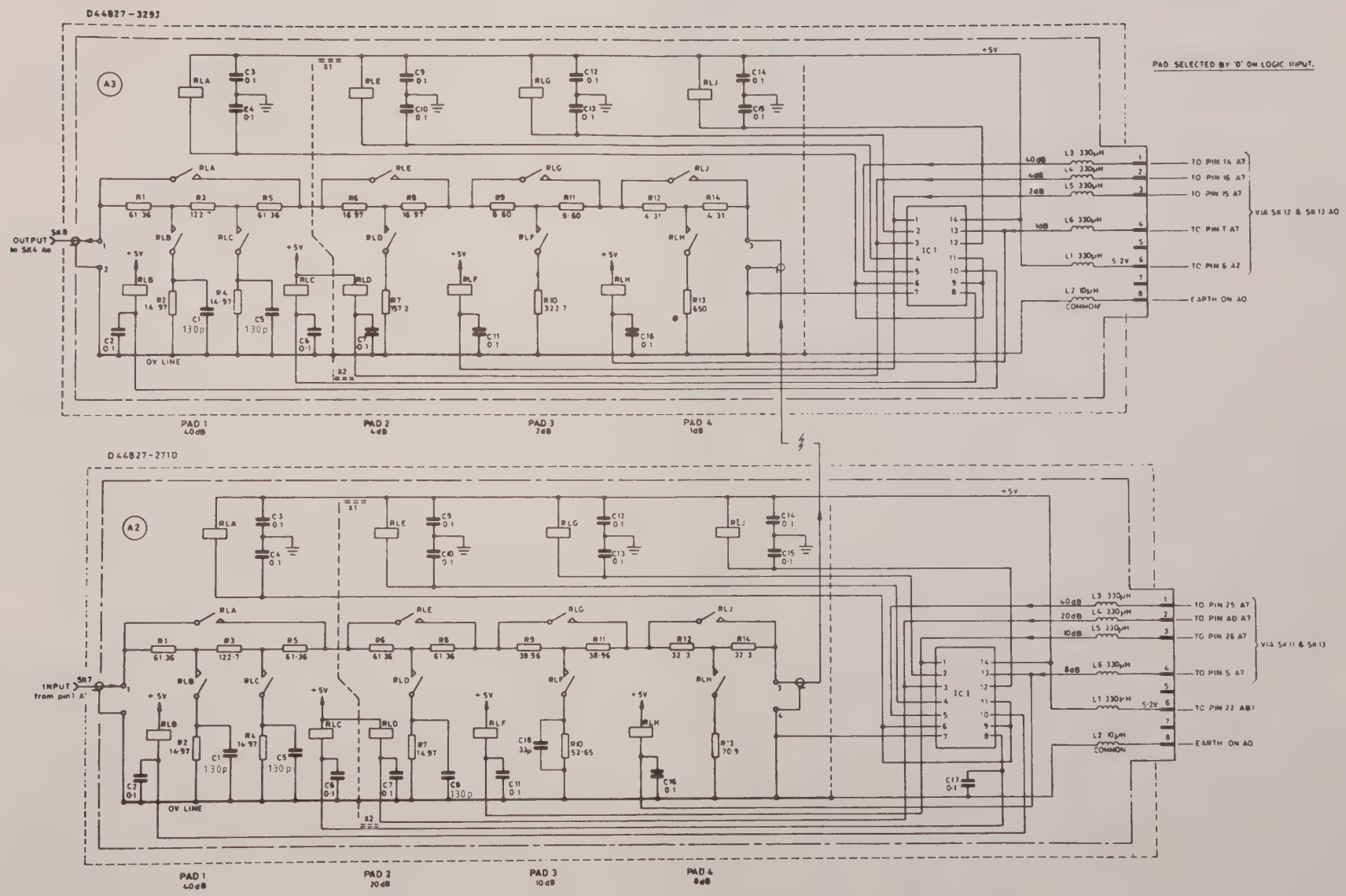


NOTE
THESE COMPONENTS ARE NOT FITTED UNTIL FINAL ASSEMBLY AND TEST STAGE D1, R2, R7, C5.

DRG.No. Z44827-320K ISS.1

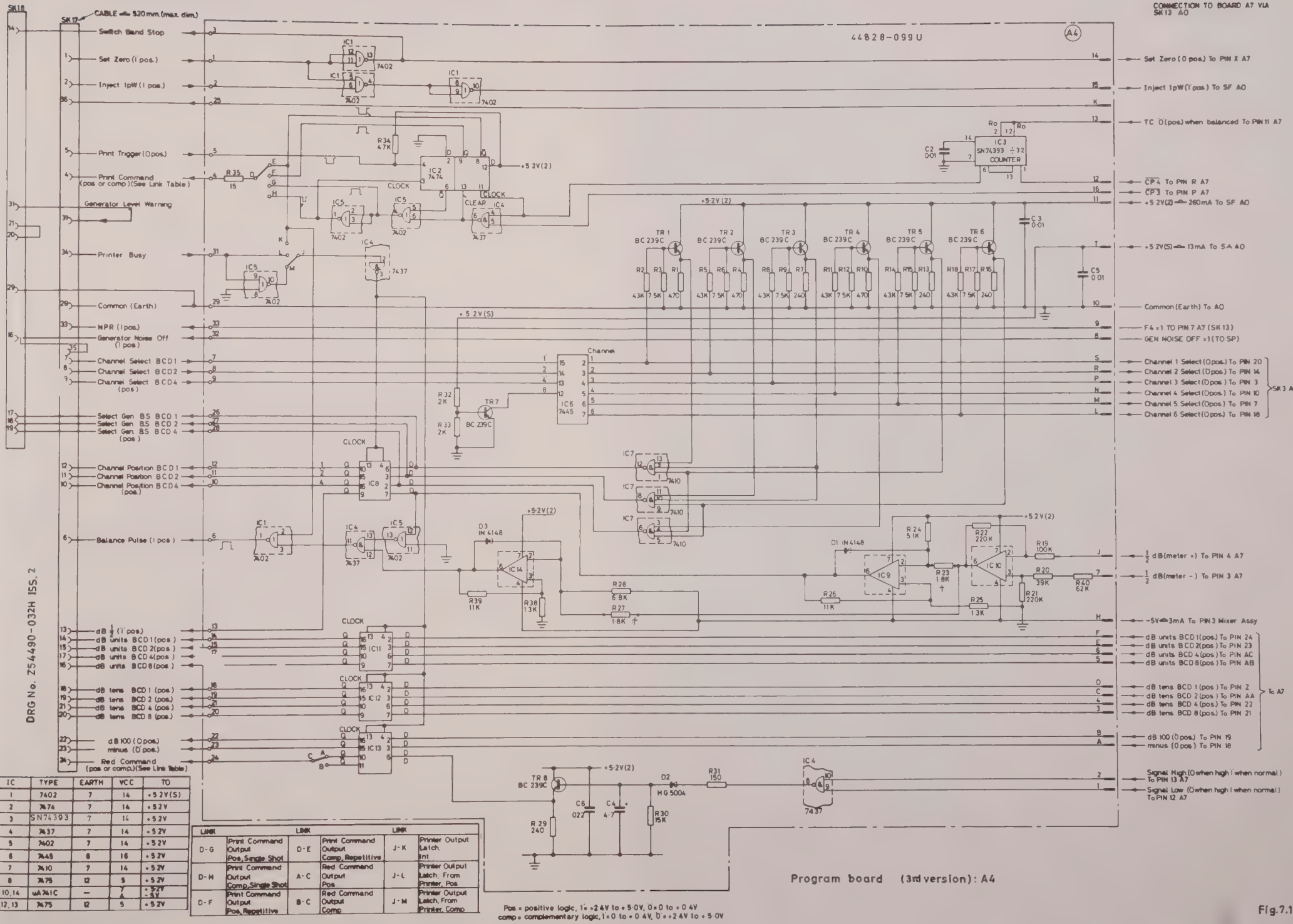
Standardizing noise source: A1

Fig. 7.9



Input attenuator: A2 and A3

Fig. 7.10
Receiver


44828-099U
A4
CONNECTION TO BOARD A7 VIA SK13 A0
SK18
SK17
CABLE = 520mm (max. dim.)
Switch Band Stop
Set Zero (1 pos.)
Inject 1pW (1 pos.)
Print Trigger (0 pos.)
Print Command (pos or comp) (See Link Table)
Generator Level Warning
Printer Busy
Common (Earth)
NPR (1 pos.)
Generator Noise Off (1 pos.)
Channel Select BCD 1
Channel Select BCD 2
Channel Select BCD 4 (pos.)
Select Gen BS BCD 1
Select Gen BS BCD 2
Select Gen BS BCD 4 (pos.)
Channel Position BCD 1
Channel Position BCD 2
Channel Position BCD 4 (pos.)
Balance Pulse (1 pos.)
dB 1/2 (1 pos.)
dB units BCD 1 (pos.)
dB units BCD 2 (pos.)
dB units BCD 4 (pos.)
dB units BCD 8 (pos.)
dB tens BCD 1 (pos.)
dB tens BCD 2 (pos.)
dB tens BCD 4 (pos.)
dB tens BCD 8 (pos.)
dB 100 (0 pos.)
minus (0 pos.)
Red Command (pos or comp.) (See Link Table)
Set Zero (0 pos.) To PIN X A7
Inject 1pW (1 pos.) To SF A0
TC 0 (pos.) when balanced To PIN 11 A7
CP4 To PIN R A7
CP3 To PIN P A7
+5.2V(2) 260mA To SF A0
+5.2V(S) 13mA To SA A0
Common (Earth) To A0
F4 ÷1 TO PIN 7 A7 (SK13)
GEN NOISE OFF ÷1 (TO SP)
Channel 1 Select (0 pos.) To PIN 20
Channel 2 Select (0 pos.) To PIN 14
Channel 3 Select (0 pos.) To PIN 3
Channel 4 Select (0 pos.) To PIN 10
Channel 5 Select (0 pos.) To PIN 7
Channel 6 Select (0 pos.) To PIN 18
SK3 A0
½ dB (meter +) To PIN 4 A7
½ dB (meter −) To PIN 3 A7
−5V 3mA To PIN 3 Mixer Assy
dB units BCD 1 (pos.) To PIN 24
dB units BCD 2 (pos.) To PIN 23
dB units BCD 4 (pos.) To PIN AC
dB units BCD 8 (pos.) To PIN AB
dB tens BCD 1 (pos.) To PIN Z
dB tens BCD 2 (pos.) To PIN AA
dB tens BCD 4 (pos.) To PIN 22
dB tens BCD 8 (pos.) To PIN 21
To A7
dB 100 (0 pos.) To PIN 19
minus (0 pos.) To PIN 18
Signal High (0 when high 1 when normal) To PIN 13 A7
Signal Low (0 when high 1 when normal) To PIN 12 A7
+5.2V(S)
+5.2V(2)
CLOCK
CLEAR
Channel
TR 1 BC 239C
TR 2 BC 239C
TR 3 BC 239C
TR 4 BC 239C
TR 5 BC 239C
TR 6 BC 239C
TR 7 BC 239C
TR 8 BC 239C
IC1 7402
IC2 7474
IC3 SN74393 ÷32 COUNTER
IC4 7437
IC5 7402
IC6 7445
IC7 7410
IC8
IC9
IC10
IC11
IC12
IC13
IC14
D1 IN4148
D2 HG5004
D3 IN4148
R34 4.7K
R35 15
R32 2K
R33 2K
R24 5.1K
R22 220K
R19 100K
R23 1.8K
R20 39K
R40 62K
R21 220K
R26 11K
R25 1.3K
R28 6.8K
R27 1.8K
R39 11K
R38 13K
R31 150
R30 15K
R29 240
C2 0.01
C3 0.01
C5 0.01
C6 022
C4 4.7
DRG No. Z54490-032H ISS. 2

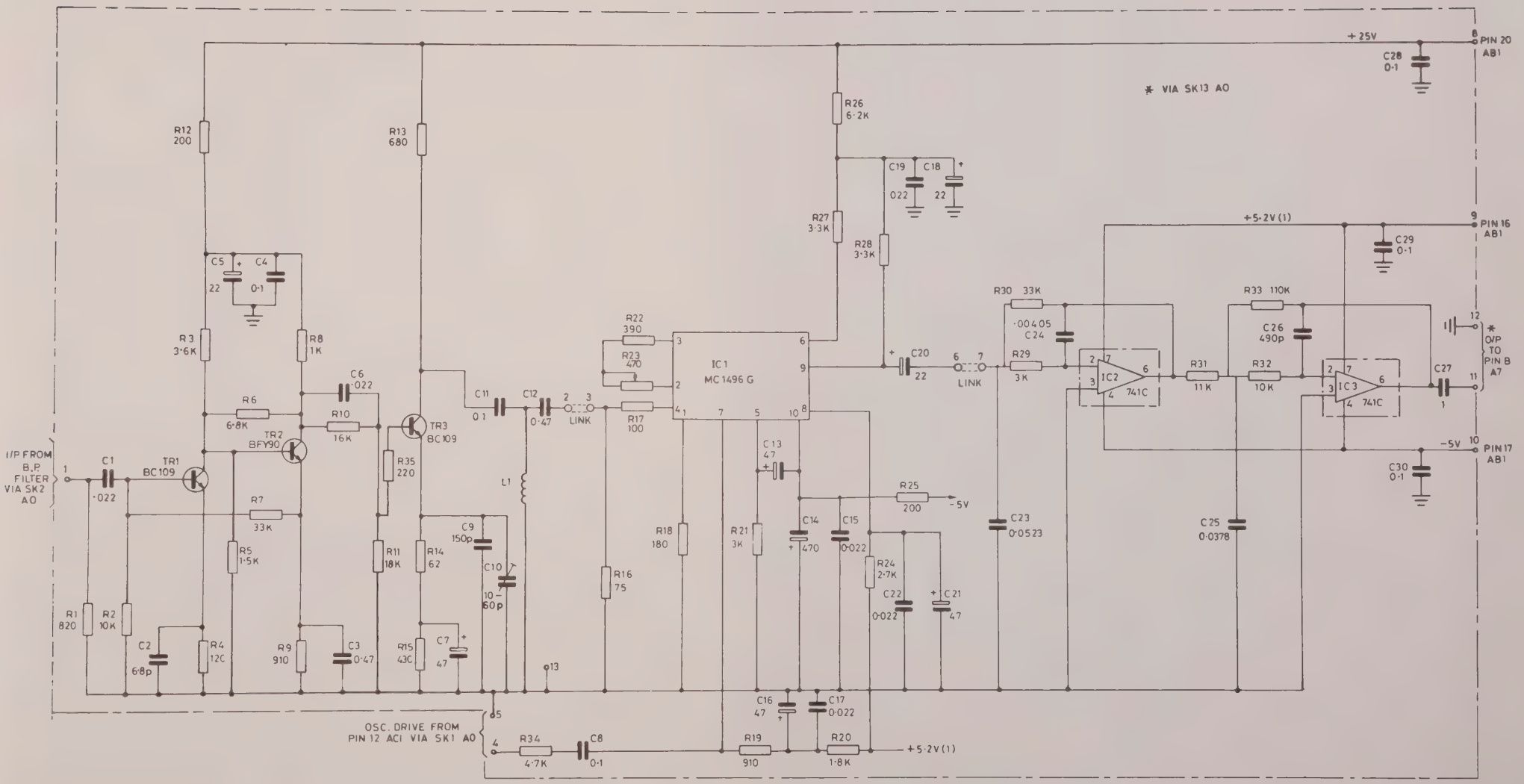
IC	TYPE	EARTH	VCC	TO
1	7402	7	14	+5.2V(S)
2	7474	7	14	+5.2V
3	SN74393	7	14	+5.2V
4	7437	7	14	+5.2V
5	7402	7	14	+5.2V
6	7445	8	16	+5.2V
7	7410	7	14	+5.2V
8	7475	12	5	+5.2V
9, 10, 14	uA741C	—	7	+5.2V
			4	−5V
11, 12, 13	7475	12	5	+5.2V

LINK		LINK		LINK	
D-G	Print Command Output Pos, Single Shot	D-E	Print Command Output Comp, Repetitive	J-K	Printer Output Latch Int
D-H	Print Command Output Comp, Single Shot	A-C	Red Command Output Pos	J-L	Printer Output Latch, From Printer, Pos
D-F	Print Command Output Pos, Repetitive	B-C	Red Command Output Comp	J-M	Printer Output Latch, From Printer, Comp

Pos = positive logic, 1 = +2.4V to +5.0V, 0 = 0 to +0.4V
comp = complementary logic, 1 = 0 to +0.4V, 0 = +2.4V to +5.0V

Program board (3rd version): A4

Fig. 7.11

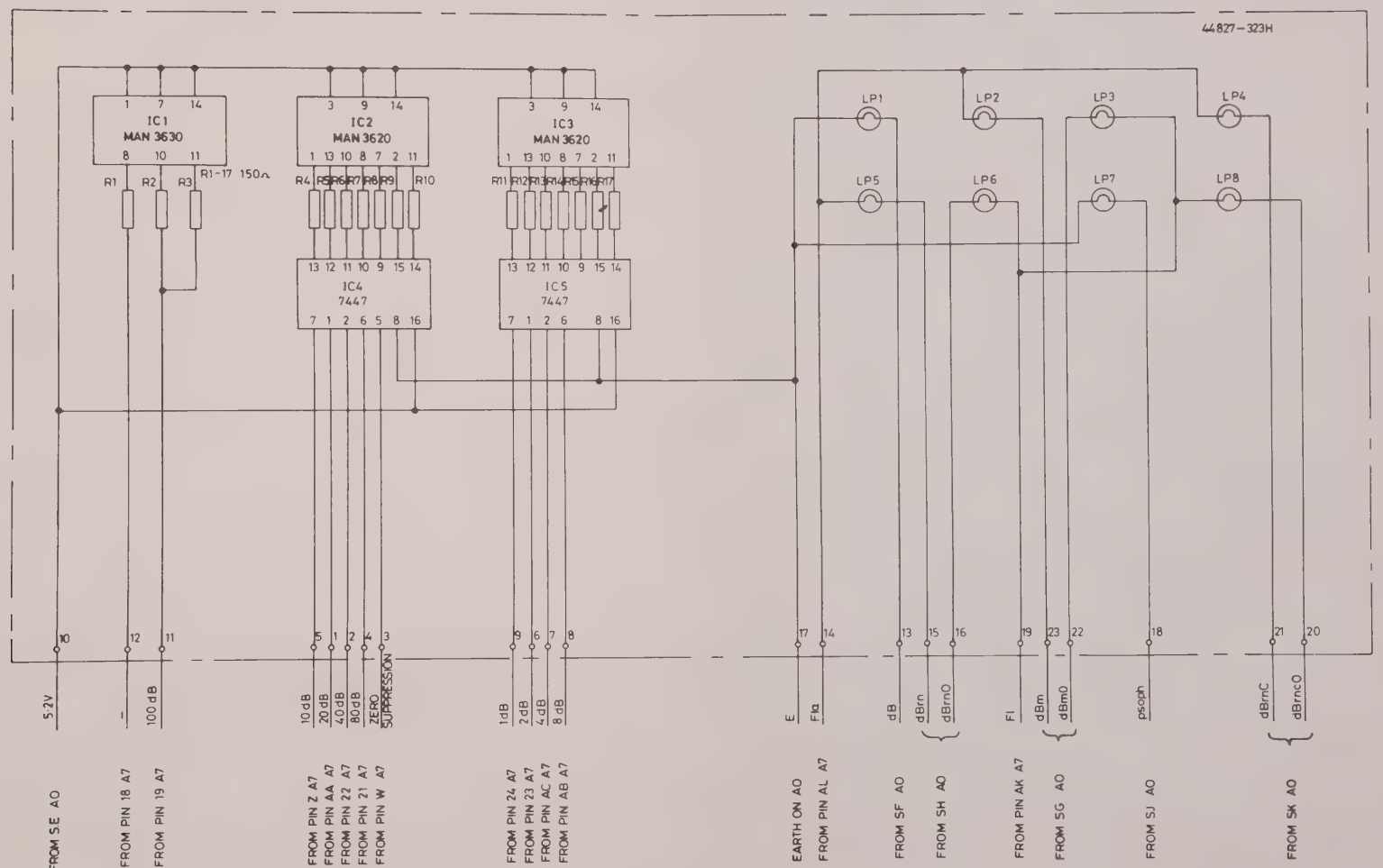


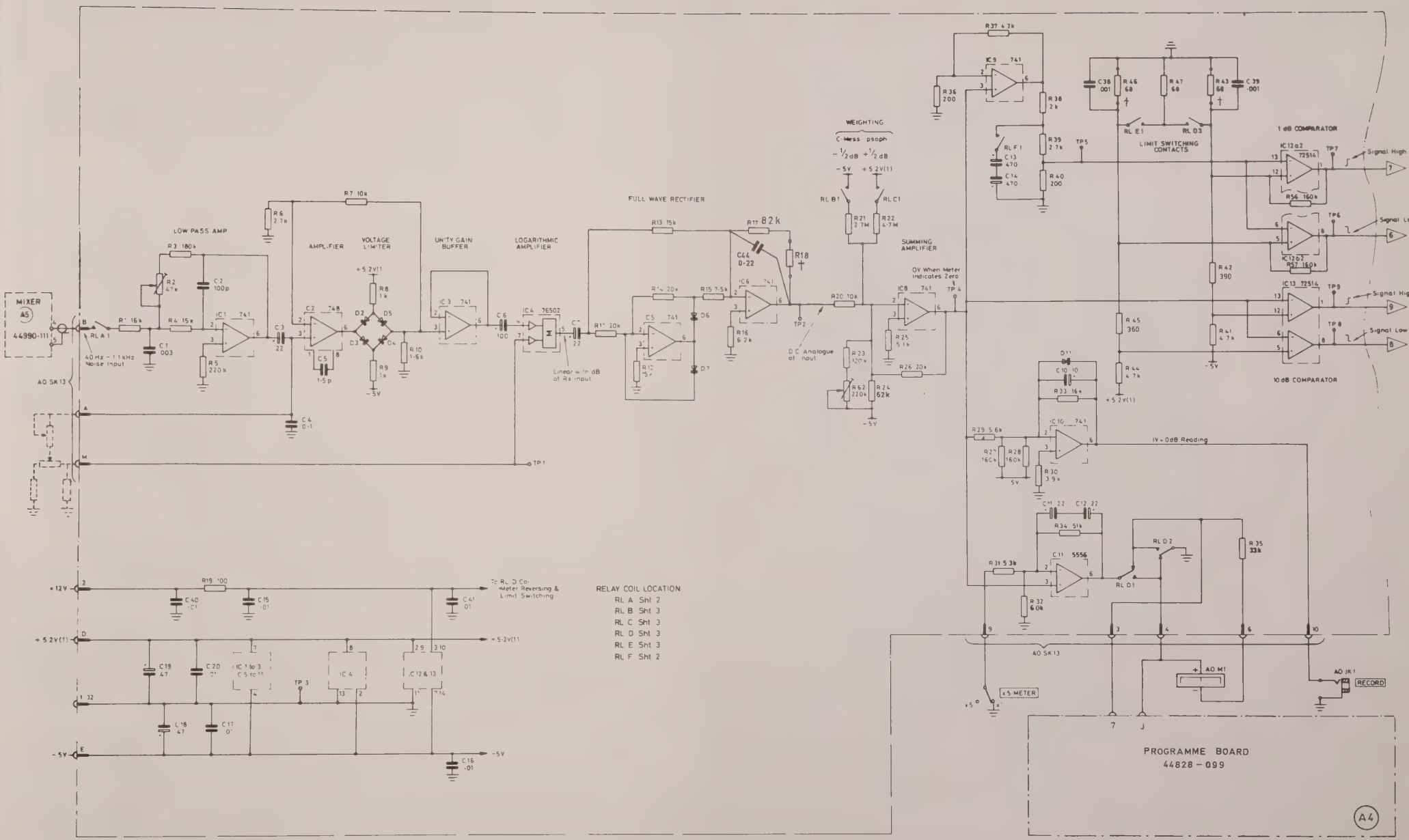
DRG. No. Z44827-322Z ISSUE 4

Mixer: A5

Fig. 7.12
Receiver

2090-930 (2a)


44827-323H
IC1
MAN 3630
IC2
MAN 3620
IC3
MAN 3620
IC4
7447
IC5
7447
R1-17 150Ω
LP1
LP2
LP3
LP4
LP5
LP6
LP7
LP8
5·2V
100 dB
10 dB
20 dB
40 dB
80 dB
ZERO SUPPRESSION
1 dB
2 dB
4 dB
8 dB
E
Fa
dB
dBrn
dBrnO
FI
dBm
dBmO
psoph
dBrnC
dBrnO
FROM SE A0
FROM PIN 18 A7
FROM PIN 19 A7
FROM PIN Z A7
FROM PIN AA A7
FROM PIN 22 A7
FROM PIN 21 A7
FROM PIN W A7
FROM PIN 24 A7
FROM PIN 23 A7
FROM PIN AC A7
FROM PIN AB A7
EARTH ON A0
FROM PIN AL A7
FROM SF A0
FROM SH A0
FROM PIN AK A7
FROM SG A0
FROM SJ A0
FROM SK A0

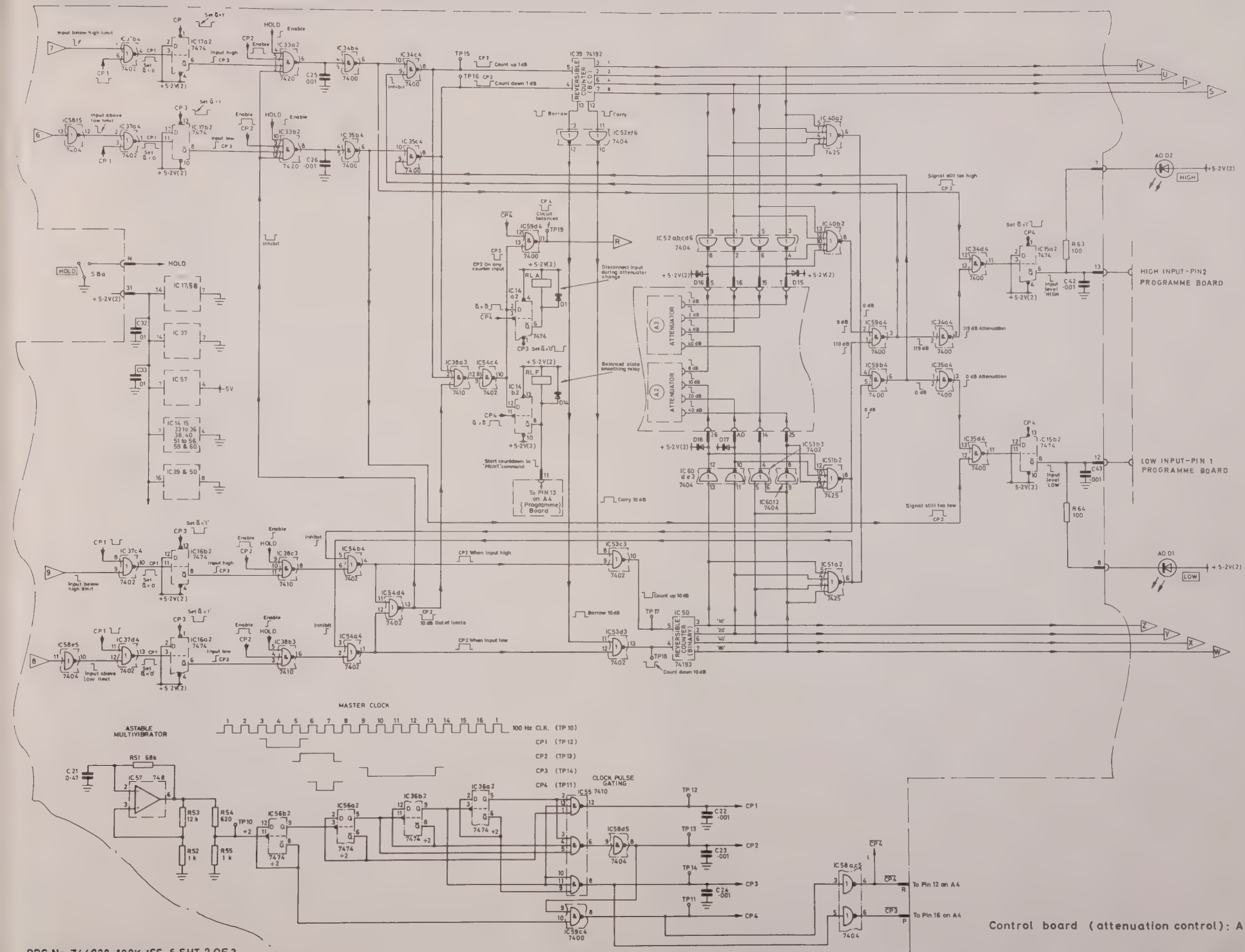


DRG. No. Z44828-100K Sht1 Iss 6

Control board (analogue circuitry): A7

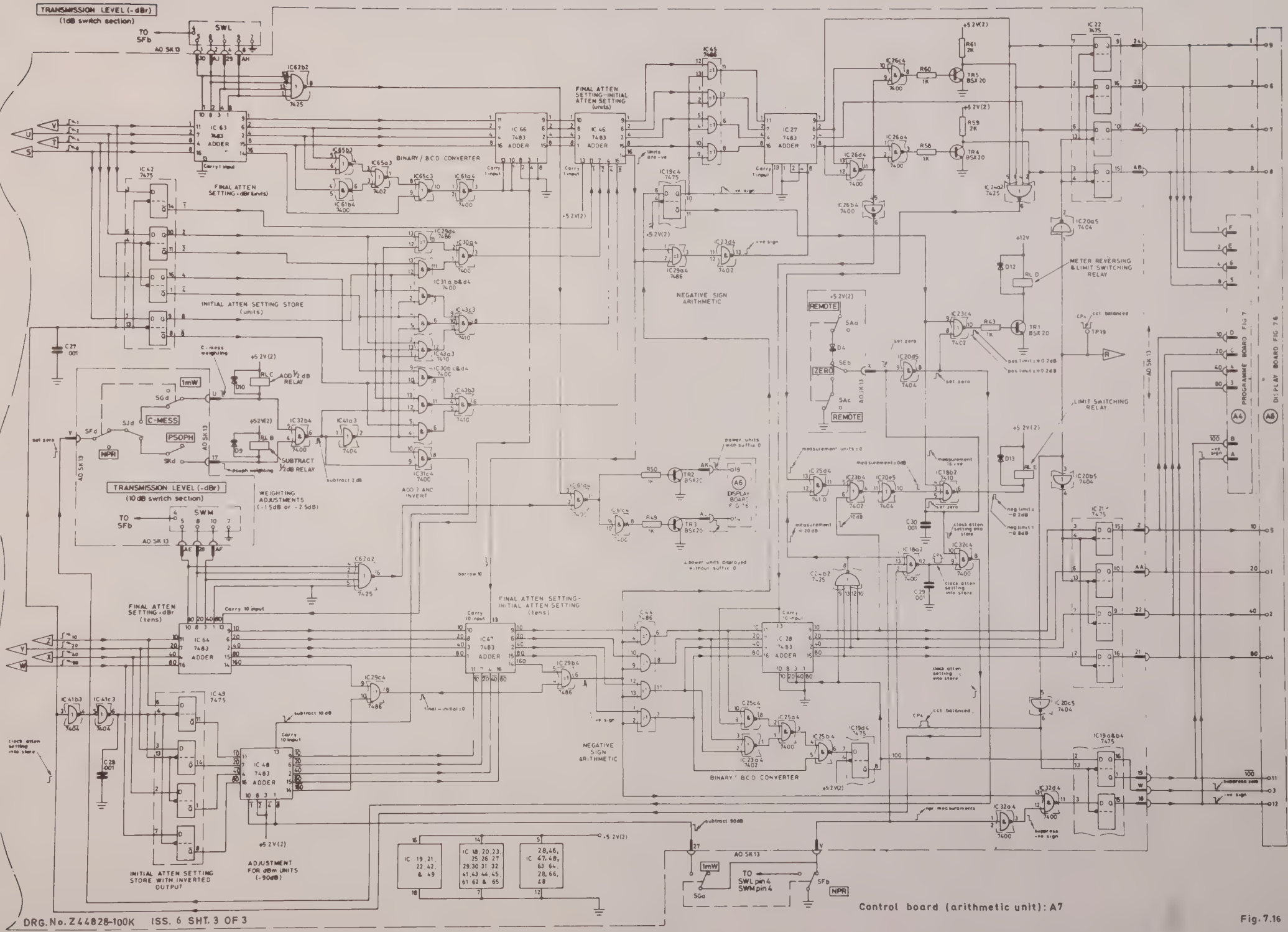
Fig.7.14

Receiver



DRG.No Z44828-100K ISS. 6 SHT 2 OF 3

Fig.7.15
Receiver

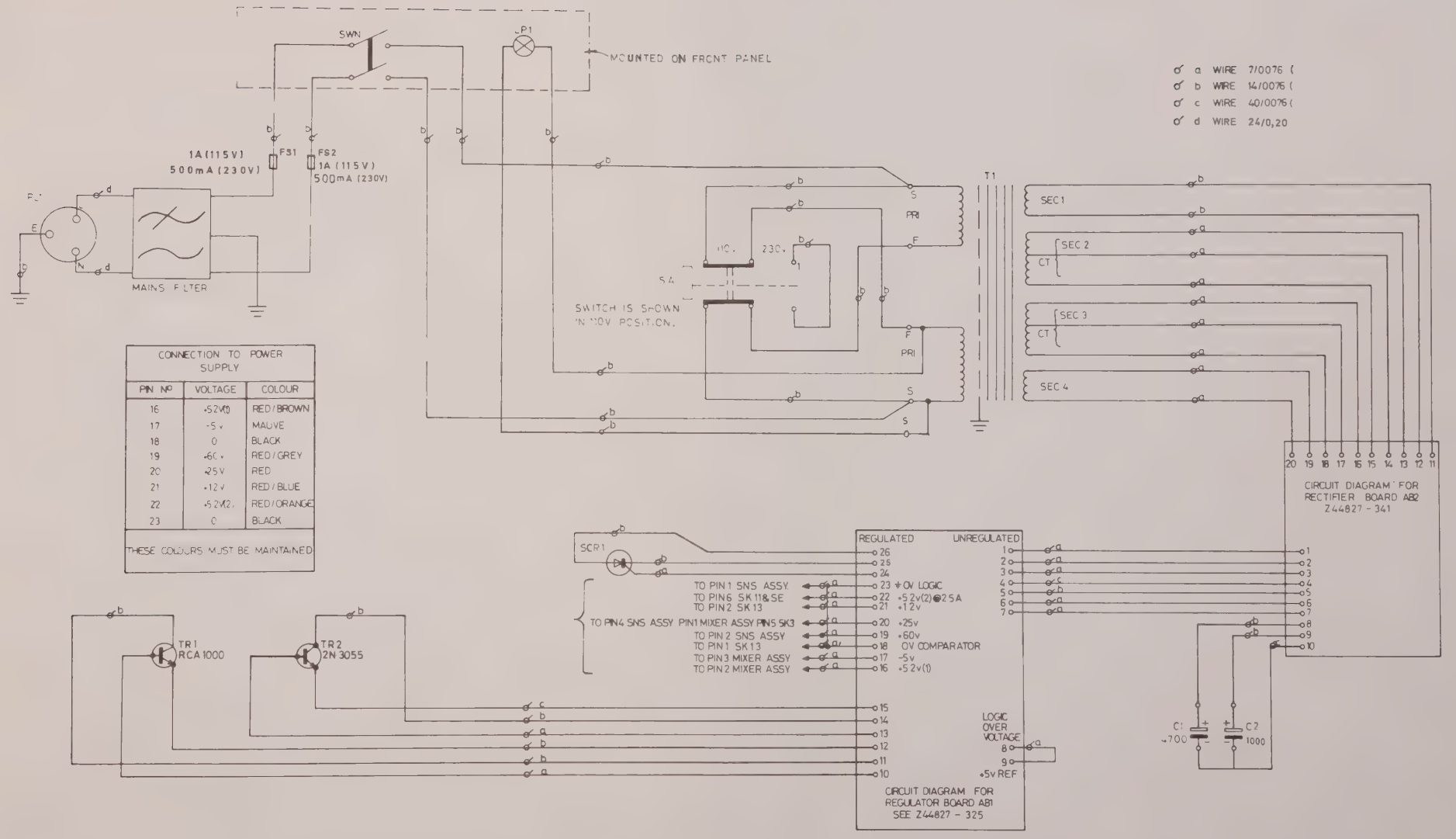


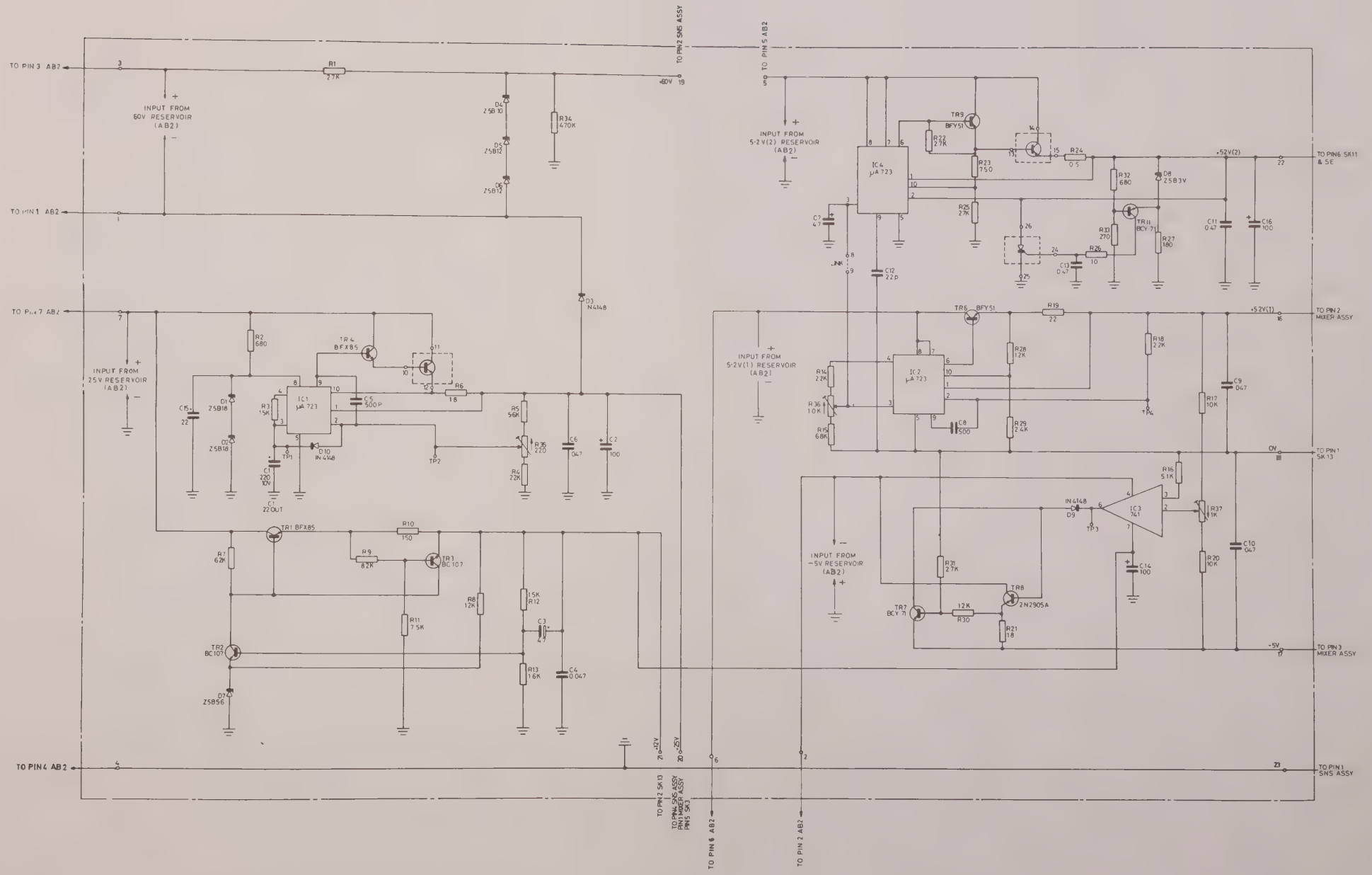
DRG. No. Z44828-100K ISS. 6 SHT. 3 OF 3

Control board (arithmetic unit): A7

Fig. 7.16

Receiver

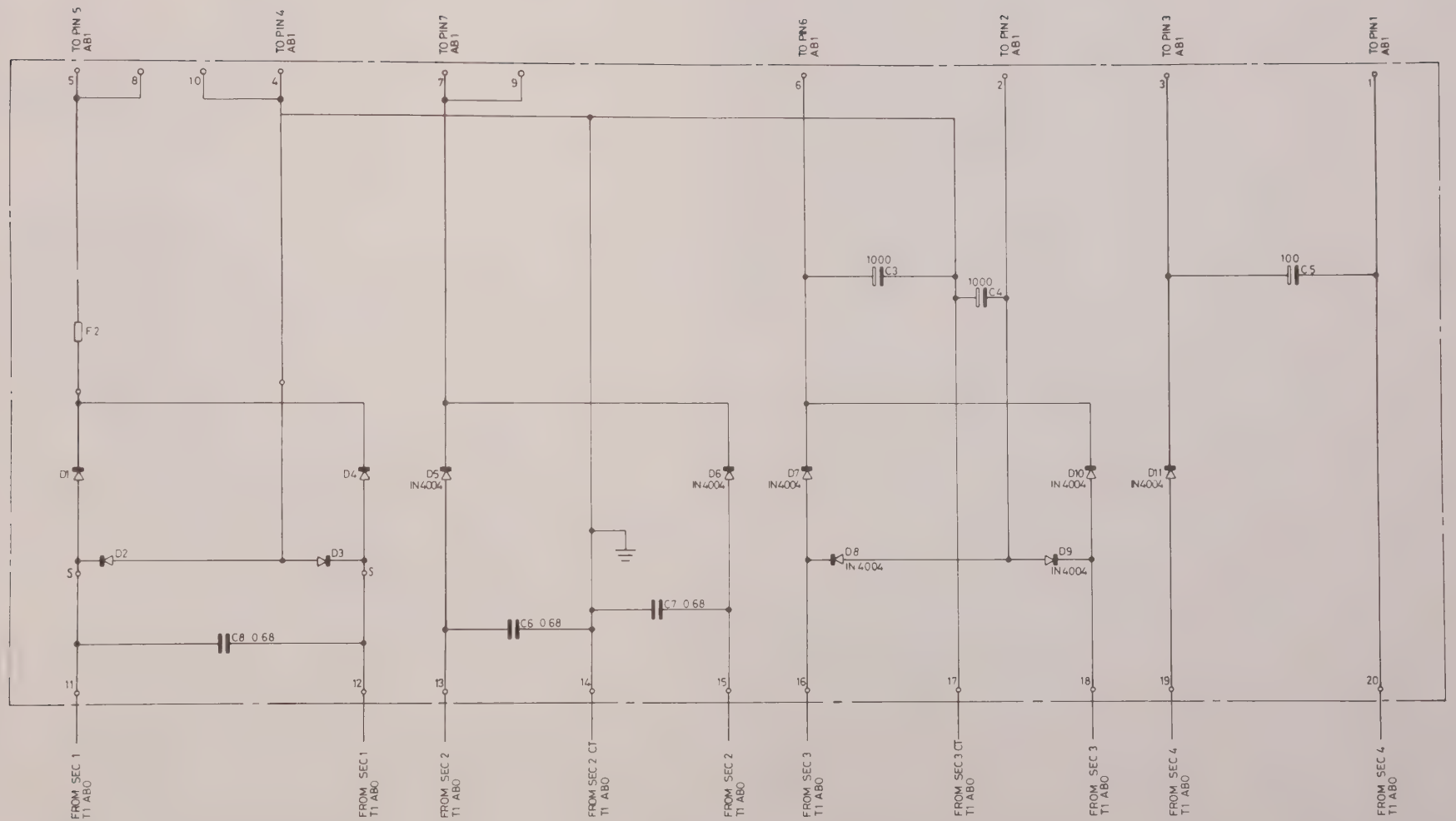

SWN
P1
MOUNTED ON FRONT PANEL
a WIRE 7/0076 (
b WIRE 14/0076 (
c WIRE 40/0076 (
d WIRE 24/0,20
1A(115V)
500mA(230V)
FS1
FS2
1A(115V)
500mA(230V)
MAINS FILTER
T1
PRI
SEC 1
SEC 2
SEC 3
SEC 4
CT
S4
SWITCH IS SHOWN IN 110V POSITION.
CONNECTION TO POWER SUPPLY
PIN No | VOLTAGE | COLOUR
16 | +52V(1) | RED/BROWN
17 | -5v | MAUVE
18 | 0 | BLACK
19 | +60v | RED/GREY
20 | +25V | RED
21 | +12v | RED/BLUE
22 | +52V(2) | RED/ORANGE
23 | 0 | BLACK
THESE COLOURS MUST BE MAINTAINED
CIRCUIT DIAGRAM FOR RECTIFIER BOARD AB2 Z44827-341
SCR1
REGULATED
UNREGULATED
TO PIN1 SNS ASSY
TO PIN6 SK11&SE
TO PIN2 SK13
TO PIN4 SNS ASSY PIN1 MIXER ASSY PIN5 SK3
TO PIN2 SNS ASSY
TO PIN1 SK13
TO PIN3 MIXER ASSY
TO PIN2 MIXER ASSY
0V LOGIC
+52v(2)@2.5A
+12v
+25v
+60v
0V COMPARATOR
-5v
+52v(1)
TR1 RCA 1000
TR2 2N3055
LOGIC OVER VOLTAGE
+5v REF
C1 4700
C2 1000
CIRCUIT DIAGRAM FOR REGULATOR BOARD AB1 SEE Z44827-325



DRG.No. Z44827-325U ISS.3

Regulator board: AB1

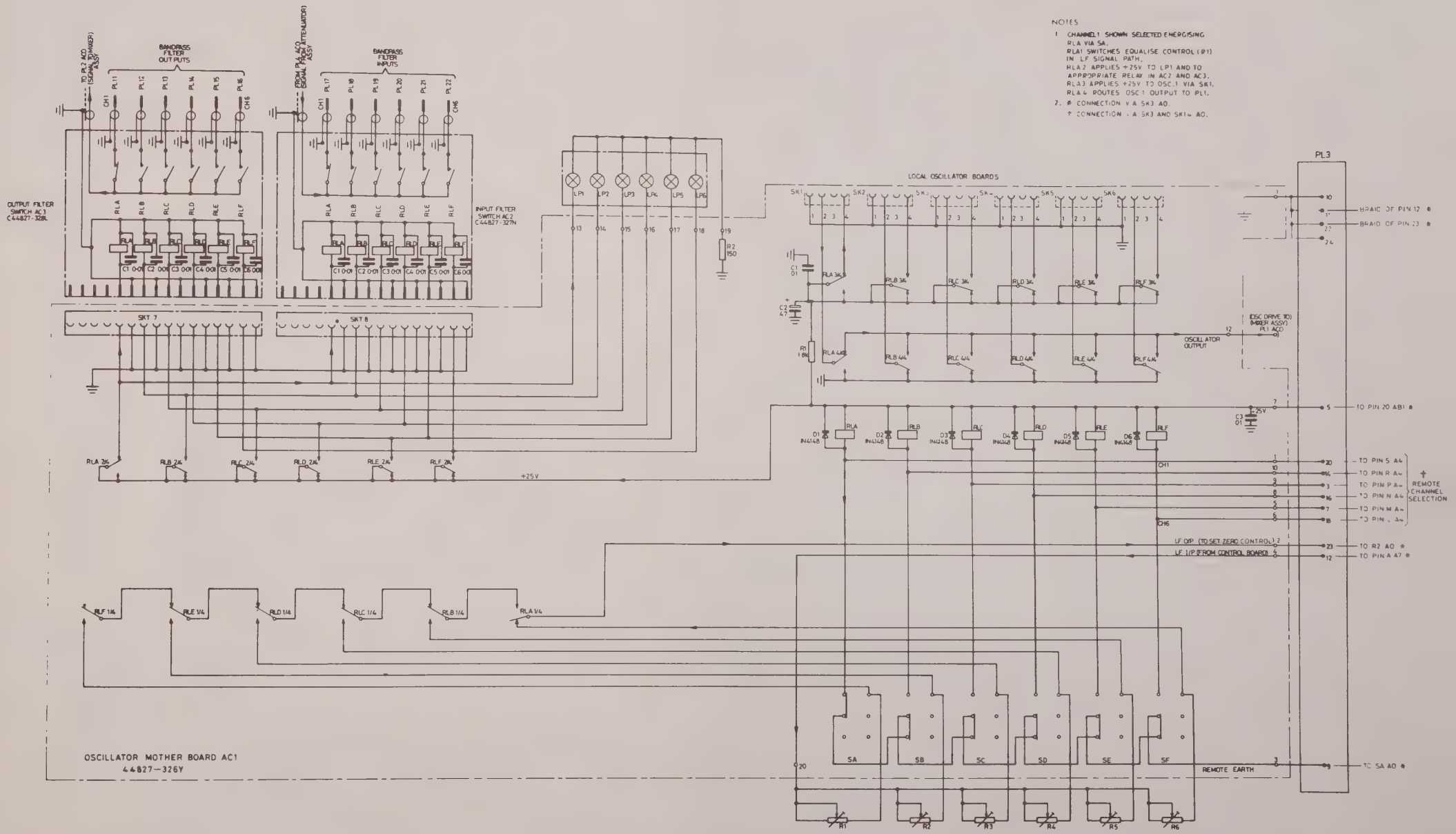
Fig.7.18



DRG. No. Z44827-341D ISS.1

Rectifier board : AB2

Fig. 7.19


NOTES
1 CHANNEL 1 SHOWN SELECTED ENERGISING RLA VIA SA. RLA1 SWITCHES EQUALISE CONTROL (R1) IN LF SIGNAL PATH. RLA2 APPLIES +25V TO LP1 AND TO APPROPRIATE RELAY IN AC2 AND AC3. RLA3 APPLIES +25V TO OSC.1 VIA SK1. RLA 4 ROUTES OSC 1 OUTPUT TO PL1.
2. # CONNECTION V A SK3 AO. † CONNECTION . A SK3 AND SK14 AO.
BANDPASS FILTER OUTPUTS
BANDPASS FILTER INPUTS
OUTPUT FILTER SWITCH AC3 C44827-328L
INPUT FILTER SWITCH AC2 C44827-327N
LOCAL OSCILLATOR BOARDS
PL3
SKT 7
SKT 8
OSCILLATOR MOTHER BOARD AC1 44827-326Y
OSCILLATOR OUTPUT
REMOTE EARTH
REMOTE CHANNEL SELECTION
+25V

FILTERS AND LOCAL OSCILLATORS

Filters which can be used with OA 2090C fall into two categories : 'B' version filters specially designed for OA 2090C and conforming with CCIR Recommendation 399-2 (Geneva 1974); additionally the earlier 'A' version filters which can be used with OA 2090C when performance to CCIR Recommendation 399 (Los Angeles 1963) is adequate.

Selective filter units of the 'B' version should be ordered as a set. Band-limiting filters, or selective filter units without 'Filter set' numbers, must be ordered as individual items. Refer to the latest data sheet and price list for full ordering information.

'A' version filters *(CCIR Recommendation 399)*

Selective filter units

Frequency (kHz)	*Band-stop filter*	*Band-pass filter*	*Local oscillator*
14	TM 7729	TM 7730	TM 7793
27	TM 7729/21	TM 7730/21	TM 7793/4
34	TM 7729/12	TM 7730/12	TM 7793/2
40	TM 7729/1	TM 7730/1	TM 7793/1
56	TM 7729/13	TM 7730/13	TM 7793/3
70	TM 7729/2	TM 7730/2	TM 7794
105	TM 7729/3	TM 7730/3	TM 7794/1
185	TM 7729/4	TM 7730/4	TM 7794/2
245	TM 7729/22	TM 7730/22	TM 7794/9
270	TM 7729/5	TM 7730/5	TM 7794/3
342	TM 7729/16	TM 7730/16	TM 7794/6
534	TM 7729/6	TM 7730/6	TM 7794/4
1002	TM 7729/15	TM 7730/15	TM 7795/5
1248	TM 7729/7	TM 7730/7	TM 7795
2438	TM 7729/8	TM 7730/8	TM 7795/1
3886	TM 7729/9	TM 7730/9	TM 7795/2
5340	TM 7729/17	TM 7730/17	TM 7795/6
8002	TM 7729/10	TM 7730/10	TM 7795/3
12150	TM 7729/11	TM 7730/11	TM 7795/4

Band-limiting filters

Frequency (kHz)	*High-pass filter*	*Frequency (kHz)*	*Low-pass filter*
12	TK 2096/2	60	TM 7720/8
60	TM 7728/1	108	TM 7720
316	TM 7728/2	156	TM 7720/14
		204	TM 7720/10
		252	TM 7720/15
		300	TM 7720/1
		552	TM 7720/2
		1052	TM 7720/11
		1300	TM 7720/3
		2660	TM 7720/12
		4028	TM 7720/5
		4188	TM 7720/13
		5564	TM 7720/9
		8204	TM 7720/6
		12388	TM 7720/7

'B' version filters *(CCIR Recommendation 399–2)*

Selective filter units

Frequency (kHz)	*Filter set*	*Band-stop filter*	*Band-pass filter*	*Local oscillator*
16	TK 2094/9	54491-101	54492-101	54493-101
40	TK 2094/10	54491-111	54492-111	54493-111
56	TK 2094/11	54491-121	54492-121	54493-121
70	TK 2094	54491-011	54492-011	54493-011
98	TK 2094/12	54491-131	54492-131	54493-131
140	TK 2094/26	54491-271	54492-271	54493-271
185	TK 2094/14	54491-151	54492-151	54493-151
240	TK 2094/15	54491-161	54492-161	54493-161
270	TK 2094/1	54491-021	54492-021	54493-021
394	TK 2094/16	54491-171	54492-171	54493-171
534	TK 2094/2	54491-031	54492-031	54493-031
770	TK 2094/19	54491-201	54492-201	54493-201
1002	TK 2094/20	54491-211	54492-211	54493-211
1248	TK 2094/3	54491-041	54492-041	54493-041
1730	TK 2094/17	54491-181	54492-181	54493-181
2438	TK 2094/4	54491-051	54492-051	54493-051
3150	TK 2094/18	54491-191	54492-191	54493-191
3886	TK 2094/5	54491-061	54492-061	54493-061
4650	TK 2094/27	54491-281	54492-281	54493-281
5340	TK 2094/6	54491-071	54492-071	54493-071
7600	TK 2094/7	54491-081	54492-081	54493-081
11700	TK 2094/8	54491-091	54492-091	54493-091

Band-limiting filters

Frequency (kHz)	*High-pass filter*	*Low-pass filter*
12	TK 2096/2	
60	TK 2096	
316	TK 2096/1	
108		TK 2095/8
156		TK 2095/18
252		TK 2095/9
300		TK 2095
408		TK 2095/12
552		TK 2095/1
804		TK 2095/13
1052		TK 2095/14
1296		TK 2095/2
1796		TK 2095/10
2600		TK 2095/3
3284		TK 2095/11
4100		TK 2095/4
4892		TK 2095/19
5600		TK 2095/5
8160		TK 2095/6
12050		TK 2095/15
12360		TK 2095/7

Out-of-band filters

(kHz)	*Filter set*	*Band-stop filter*	*Band-pass filter*	*Local oscillator*
10	TK 2084	54494-011	54495-011	54496-011
50	TK 2084/1	54494-021	54495-021	54496-021
119	TK 2084/2	54494-031	54495-031	54496-031
270	TK 2084/3	54494-041	54495-041	54496-041
304	TK 2084/4	54494-051	54495-051	54496-051
331	TK 2084/5	54494-061	54495-061	54496-061
600	TK 2084/6	54494-071	54495-071	54496-071
607	TK 2084/7	54494-081	54495-081	54496-081
1499	TK 2084/8	54494-091	54495-091	54496-091
1549	TK 2084/9	54494-101	54495-101	54496-101
3200	TK 2084/10	54494-111	54495-111	54496-111
3250	TK 2084/11	54494-121	54495-121	54496-121
4715	TK 2084/12	54494-131	54495-131	54496-131
4765	TK 2084/13	54494-141	54495-141	54496-141
6199	TK 2084/14	54494-151	54495-151	54496-151
6300	TK 2084/15	54494-161	54495-161	54496-161
9023	TK 2084/16	54494-171	54495-171	54496-171
9073	TK 2084/17	54494-181	54495-181	54496-181
13677	TK 2084/2	54494-221	54495-221	54496-221

Corrections for 'B' version filters

For use with Sect. 2.6

Reduce the generator meter reading by the amount in dB shown in this table.

System capacity (channels)		24	60	60	96	120	132	192	252	300	432	600	612	792	900	960	972	1200	1260	1800	1872	2700
Baseband (kHz)		12-108	12-252	60-300	12-108	60-552	12-552	12-804	12-1052	60-1296	12-1796	60-2600	12-2600	12-3284	316-4100	60-4100	12-4100	316-5600	60-5600	316-8160	12-8160	316-12360
Band stop filter																						
Part of Set TK	Frequency (kHz)																					
2094/9	16	0.40	0.15	-	0.10	-	0.05	0.05	0.05	-	0	-	0	0	-	-	0	-	-	-	-	-
2094/10	40	0.30	0.10	-	0.05	-	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2094/11	56	0.30	0.10	-	0.05	-	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2094	70	-	0.45	0.40	0.25	0.20	0.20	0.15	0.10	0.10	0.05	0.05	0.05	0.05	-	0.05	0.05	-	0	-	0	-
2094/12	98	0.30	0.15	0.15	0.10	0.05	0.05	0.05	0.05	0	-	-	-	-	-	-	-	-	-	-	-	-
2094/14	185	-	0.15	0.15	0.10	0.05	0.05	0.05	0.05	0.05	0	0	0	-	-	-	-	-	-	-	-	-
2094/15	240	-	0.15	0.15	0.10	0.10	0.05	0.05	0.05	0.05	0	0	0	-	-	-	-	-	-	-	-	-
2094/1	270	-	-	0.25	0.15	0.10	0.10	0.05	0.05	0.05	0.05	0	0	0	-	0	0	-	0	-	-	-
2094/16	394	-	-	-	0.15	0.15	0.15	0.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2094/2	534	-	-	-	-	0.25	0.25	0.15	0.10	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0	0
2094/19	770	-	-	-	-	-	-	0.20	0.15	0.10	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0	0	-	-	-
2094/20	1002	-	-	-	-	-	-	-	0.20	0.20	0.10	0.10	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0	0
2094/3	1248	-	-	-	-	-	-	-	-	0.20	0.15	0.10	0.10	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0	0
2094/17	1730	-	-	-	-	-	-	-	-	-	0.20	0.15	0.15	0.10	0.10	0.10	0.10	0.05	0.05	-	-	-
2094/4	2438	-	-	-	-	-	-	-	-	-	-	0.20	0.20	0.15	0.15	0.15	0.15	0.10	0.10	0.05	0.05	0.05
2094/18	3150	-	-	-	-	-	-	-	-	-	-	-	-	0.30	0.20	0.15	0.15	0.10	0.10	0.10	0.10	0.05

At 3886 kHz and above the insertion loss is negligible and no correction is required.

Corrections for 'A' version filters

For use with Sect. 2.6

Reduce the generator meter reading by the amount in dB shown in this table.

System capacity (channels)		12	24	36	48	60	60	120	132	240	300	600	900	960	1200	1260	1800	2700
Baseband (kHz)		12-60	12-108	12-156	12-204	12-252	60-300	60-552	12-552	60-1052	60-1300	60-2660	316-4188	60-4028	316-5564	60-5564	316-8204	316-12388
Band stop filter																		
Part of	Frequency (kHz)																	
TM 7729	14	0.6	0.3	0.2	0.2	0.1	-	-	0	-	-	-	-	-	-	-	-	-
TM 7729/21	27	1.0	0.5	0.3	0.3	0.2	-	-	0.1	-	-	-	-	-	-	-	-	-
TM 7729/12	34	0.9	0.5	0.3	0.2	0.2	-	-	0.1	-	-	-	-	-	-	-	-	-
TM 7729/1	40	1.0	0.5	0.4	0.3	0.2	-	-	0.1	-	-	-	-	-	-	-	-	-
TM 7729/13	56	1.0	0.6	0.5	0.3	0.3	-	-	0.1	-	-	-	-	-	-	-	-	-
TM 7729/2	70	-	0.8	0.5	0.4	0.3	0.3	0.2	0.1	0.1	0.1	0	-	0	-	0	-	-
TM 7729/3	105	-	0.6	0.7	0.5	0.4	0.4	0.2	0.2	0.1	0.1	0	-	0	-	0	-	-
TM 7729/4	185	-	-	-	0.6	0.4	0.4	0.2	0.2	0.1	0.1	0	-	0	-	0	-	-
TM 7729/22	245	-	-	-	-	0.4	0.5	0.2	0.2	0.1	0.1	0	-	0	-	0	-	-
TM 7729/5	270	-	-	-	-	-	0.5	0.3	0.2	0.1	0.1	0	-	0	-	0	-	-
TM 7729/6	534	-	-	-	-	-	-	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0	0	0	0
TM 7729/15	1002	-	-	-	-	-	-	-	-	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0	0
TM 7729/7	1248	-	-	-	-	-	-	-	-	-	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0
TM 7729/8	2438	-	-	-	-	-	-	-	-	-	-	0.3	0.2	0.2	0.1	0.1	0.1	0.1
TM 7729/9	3886	-	-	-	-	-	-	-	-	-	-	-	0.3	0.3	0.2	0.2	0.2	0.1
TM 7729/17	5340	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	0.3	0.2	0.1
TM 7729/10	8002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	0.2
TM 7729/11	12150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3

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